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INFRASOUND AND THE INFRASONIC MONITORING OF ATMOSPHERIC NUCLEAR EXPLOSIONS:

Supporting Environmental Data

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13. ABSTRACT *(Maximum 200 words)*

This is a data report which provides temperature, wind speed, sound speed, effective sound speed and mean global cloud cover data for use by those involved in monitoring compliance with a CTBT (Comprehensive Test Ban Treaty) and, in particular, for those concerned with infrasonic monitoring *per se*.

The temperature, wind speed, sound speed and effective sound speed data are zonally averaged data obtained from the COSPAR (Committee on Space Research) International Reference Atmosphere: 1986 (0 km to 120 km) [*CIRA* (1986)]. The data set is available from NASA's National Space Science Data Center, includes only the lower atmospheric altitude range extending from 0 km to 120 km and consists of tables of monthly mean values of temperature and zonally averaged wind speed for the latitude range 80°S to 80°N in 10 degree intervals.

The mean global cloud cover data are presented as contours of cloud fraction and were obtained from three sources: (1) International Satellite Cloud Climatology Project (ISCCP); (2) the Atlas of Surface Marine Data - 1994 [*daSilva, Young and Levitus* (1994)]; and (3) the Global Distribution of the Total Amount of Cloudiness [*Berliand and Strokina* (1981)].

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In addition to the presentation of the environmental data, a general background discussion on the atmosphere and its influence on sound propagation is provided.

ACKNOWLEDGMENTS

The author would like to express his sincere appreciation to Dr. Robert Blandford of the AFTAC for suggesting this work and to Ms. Leslie Casey of the DOE for her support and encouragement during its conduct.

1.0 INTRODUCTION

This is a data report which provides temperature, wind speed, sound speed, effective sound speed and cloud cover data for use by those involved in monitoring compliance with a CTBT (Comprehensive Test Ban Treaty) and, in particular, for those concerned with infrasonic monitoring *per se*. The report is one of four resulting from a DOE (Department of Energy) sponsored seventeen month investigation and review of past work in infrasound. Other project related reports include: an annotated bibliography of selected papers in infrasound [*McKisic* (1996a)]; a review of past work in the infrasonic monitoring of atmospheric nuclear explosions [*McKisic* (1996b)]; and a comprehensive literature review on infrasound and infrasonic monitoring [*McKisic* (1997)].

For purposes of exposition, the report is divided into five main sections and two appendices. In this section, a general background discussion on the atmosphere and its influence on sound propagation is provided. Section 2.0 consists of four subsections which present graphs of monthly and zonally averaged temperature, wind speed, sound speed and effective sound speed atmospheric profiles constructed from data available in the *CIRA* (1986) [COSPAR International Reference Atmosphere] data set. Section 3.0 consists of three subsections which present monthly and global maps of total cloud cover (or cloud fraction) contours based on data obtained from the Lamont Doherty Geophysical Laboratory of Columbia University on the internet [http://ingrid.ldgo.columbia.edu]. The cloud cover data, while not strictly applicable to infrasound propagation in the atmosphere, are of interest to the monitoring of atmospheric nuclear explosions because potential violators may choose to test in those areas exhibiting dense cloud cover with the goal of avoiding satellite detection. Section 4.0 presents a brief discussion of results and Section 5.0 provides a listing of the references cited in the main body of the text. Appendices A and B present numerical values of zonally averaged sound and wind speed, respectively, for each month of the year.

The long range propagation of sound in the atmosphere is controlled by the latter's distributions of temperature and wind velocity as a function of height above the earth's surface and as a function of horizontal range. In the absence of wind, temperature is the controlling factor as it determines sound speed in a gas such as the earth's atmosphere through *Laplace's* relation

$$c = (\gamma p / \rho)^{1/2} \tag{1.1}$$

where γ is the ratio of the specific heat of air at constant pressure to the specific heat at constant volume (i.e., $\gamma = C_p/C_V$), p is the pressure and ρ is the density. For an ideal gas, the equation of state can be written

$$p = \frac{\rho RT}{M} \tag{1.2}$$

where R is the universal gas constant [=8.314 joule/(mole)(K^o)], T is the absolute temperature and M is the molecular weight of the gas. Substitution of (1.2) into (1.1) leads to the expression

$$c = \left(\frac{\gamma RT}{M}\right)^{1/2}. \tag{1.3}$$

For dry air, $\gamma = 1.403$, and $M = 2.897 \times 10^{-2}$ kg/mole so that, numerically, Eq. (1.1) becomes

$$c \approx 20.07\sqrt{T}. \tag{1.4}$$

Figure 1 provides the details of the temperature structure of the earth's atmosphere as a function of height from the surface of the earth to an altitude of 400 km based on data for the U.S. Standard Atmosphere 1976 [*NOAA/NASA/USAF* (1976)]. The figure is useful for indicating the approximate heights of the atmosphere's major divisions: troposphere, stratosphere, mesosphere and thermosphere. Figure 2 provides more detail on the temperature structure of the earth's atmosphere from the surface of the earth to an altitude of 120 km which is the most important region for acoustic propagation and, accordingly, for issues involving the infrasonic monitoring of atmospheric nuclear explosions.

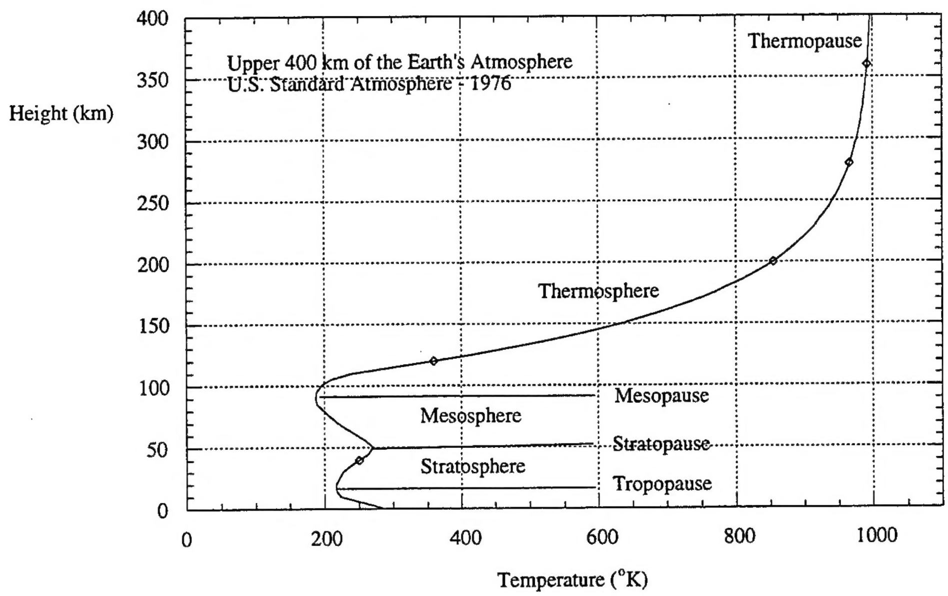

Figure 1. The temperature structure of the earth's atmosphere from the surface of the earth to an altitude of 400 km based on the conventions of the U.S. Standard Atmosphere 1976 [*NOAA, NASA, USAF* (1976)].

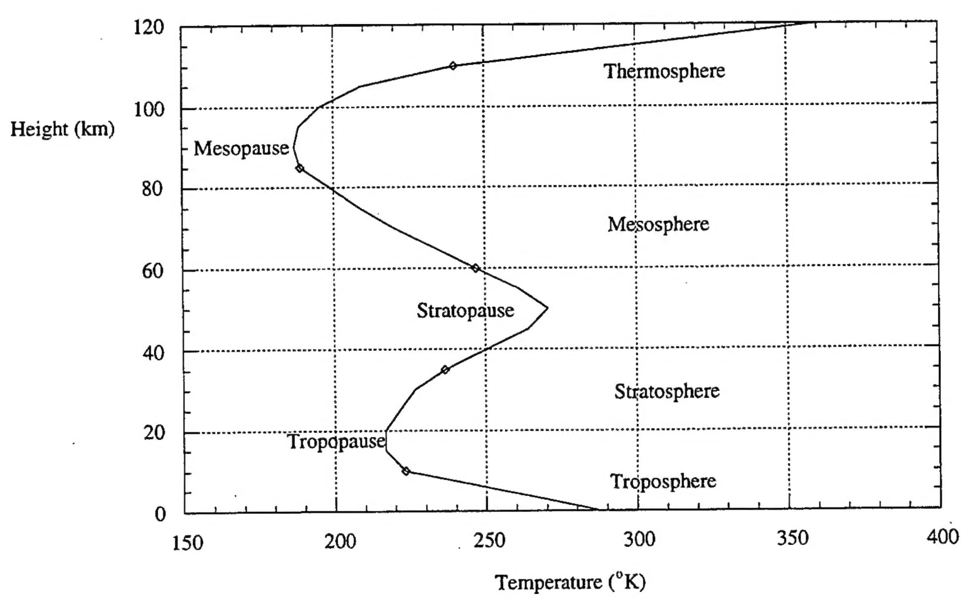

Figure 2. The temperature of the earth's atmosphere from the earth's surface to an altitude of 120 km based on the conventions of the U.S. Standard Atmosphere 1976 [*NOAA/NASA/USAF* (1976)].

As indicated in the figures, temperature decreases with increasing height in the troposphere (literally, "the turning or changing sphere") or lowest part of the atmosphere until a region is reached at approximately 15 km in altitude in which the temperature remains constant with increasing height: the tropopause. As discussed, for example, by *Wallace and Hobbs* (1976), *Kato* (1981) and by *Gill* (1982), the troposphere or "convective layer" is characterized by strong vertical mixing and contains more than 80% of the atmosphere's mass. The region accounts for virtually all of the earth's water vapor and clouds as well as all precipitation and thunderstorm activity. The decrease in temperature with increasing height in the troposphere is primarily caused by the thermodynamics of adiabatic expansion.

Above the tropopause, in the region referred to as the stratosphere (literally, "the layered sphere") temperature increases with increasing height until another region is reached, at approximately 50 km in altitude, where the temperature remains constant with increasing height: the stratopause. The stratosphere, together with the troposphere contain approximately 99% of the atmospheric mass. The stratosphere is physically characterized by very small vertical mixing as is evident from the very abrupt decrease in water vapor concentration and increase in ozone concentration occurring at the tropopause-stratosphere boundary, and by the observed long residence times of volcanic and nuclear explosion debris. The reason that the temperature increases with increasing height in the stratosphere is "due to radiative heating by ozone O_3. The heat balance is established between ultraviolet absorption of O_3 and infrared radiation from water vapor (H_2O), carbon dioxide (CO_2) and O_2". [*Kato* (1981)].

Above the stratopause, in the region referred to as the mesosphere, the temperature again decreases with increasing height until another region is reached, at an altitude of approximately 90 km, in which the temperature remains constant with increasing altitude: the mesosphere. The observed mesospheric decrease in temperature with increasing height

is due to "radiative heating by dissociation of molecular oxygen in the lower thermosphere, and by ionization of O, etc," [*Kato* (1981)].

The mesosphere (literally "middle sphere"), like the troposphere, is characterized by vertical mixing and "during summer there is sometimes enough lifting to produce thin cloud layers in the upper mesosphere over parts of the polar regions. Under ordinary conditions the concentrations in these clouds are far too small to render them visible from the ground. However, at twilight mesospheric clouds are sometimes still in sunlight while the lower atmosphere is in the earth's shadow. Under such conditions such clouds are visible from the ground as *noctilucent clouds*" [*Wallace and Hobbs* (1977)].

Finally, above the mesopause, there is the thermosphere which extends to a height of 1000 km and in which the temperature increases with increasing height until an asymptote is reached, at an altitude of approximately 500 km, which is essentially isothermal: the thermopause. The temperature distribution of the thermosphere above 120 km is controlled by solar activity and the asymptotic temperature ranges between 500^oK (a "quiet sun") and 2000^oK (an "active sun"). The solar activity for the U.S. Standard Atmosphere 1976 is taken to be moderate as the asymptotic temperature is seen to be 1000^oK.

Figure 3 provides the sound speed profile of the earth's atmosphere from the earth's surface to an altitude of 120 km based on data from the U.S. Standard Atmosphere 1976 model and as computed from Eq. (1.4). The profile is seen to be inhomogeneous and characterized by two channels, the axes of which are located at the approximate altitudes of 18 km and 90 km. The fact that the profile is inhomogeneous implies that acoustic propagation will be controlled by refraction (i.e., the acoustic ray paths will not correspond to straight lines) and the existence of sound channels implies that, under the appropriate conditions, acoustic energy can be trapped in the channels and propagated to significant ranges. The channels are the atmospheric analog to the well known SOFAR (Sound Fixing and Ranging) channel in the ocean which is responsible for the very efficient and long

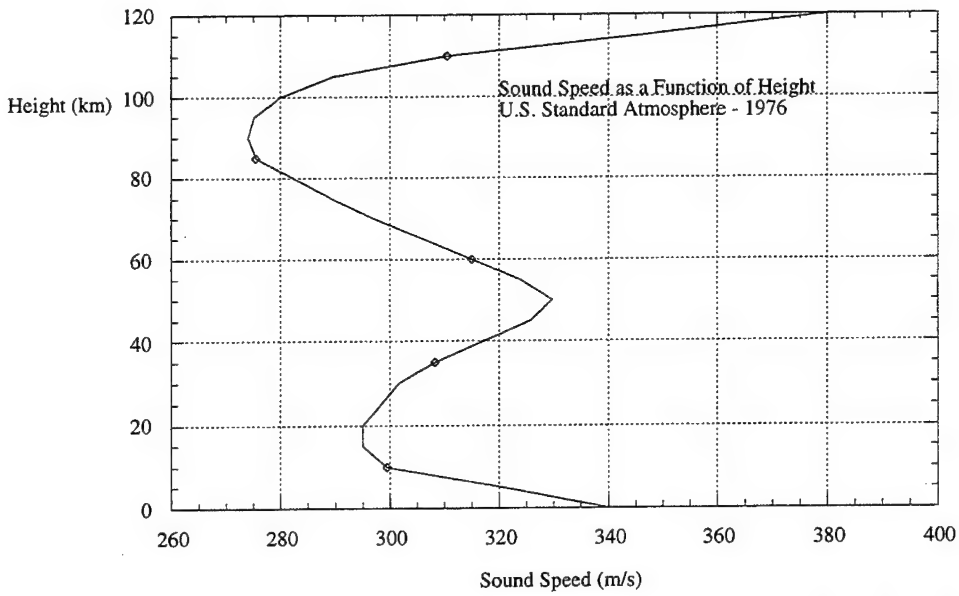

Figure 3. Sound speed (m/s) as a function of height for the U.S. Standard Atmosphere 1976 [*NOAA/NASA/USAF* (1976)]. As indicated, there are two distinct sound channels: a lower channel with an axis at approximately 18 km and an upper sound channel with an axis at approximately 90 km height.

range low frequency propagation of acoustic energy in that medium. Figure 4 provides a ray trace for acoustic energy propagating from a source located on the earth's surface to a horizontal range of 1000 km. As indicated, there are reflections from both the stratosphere and the ionosphere.

In addition to temperature, the other variable which controls acoustic propagation in the atmosphere is the wind which determines the effective sound speed, c_{eff}, through the relation

$$c_{eff} = c_T + \mathbf{n} \cdot \mathbf{v} \tag{1.5}$$

where in the above, c_T, is the contribution due to temperature and the last term is the contribution of the wind. The latter contribution enters as the "dot product" of a unit vector in the direction of propagation, **n**, and the vector wind velocity, **v**. The wind velocity is, in general, a strong function of height in the atmosphere, season, time of day and location.

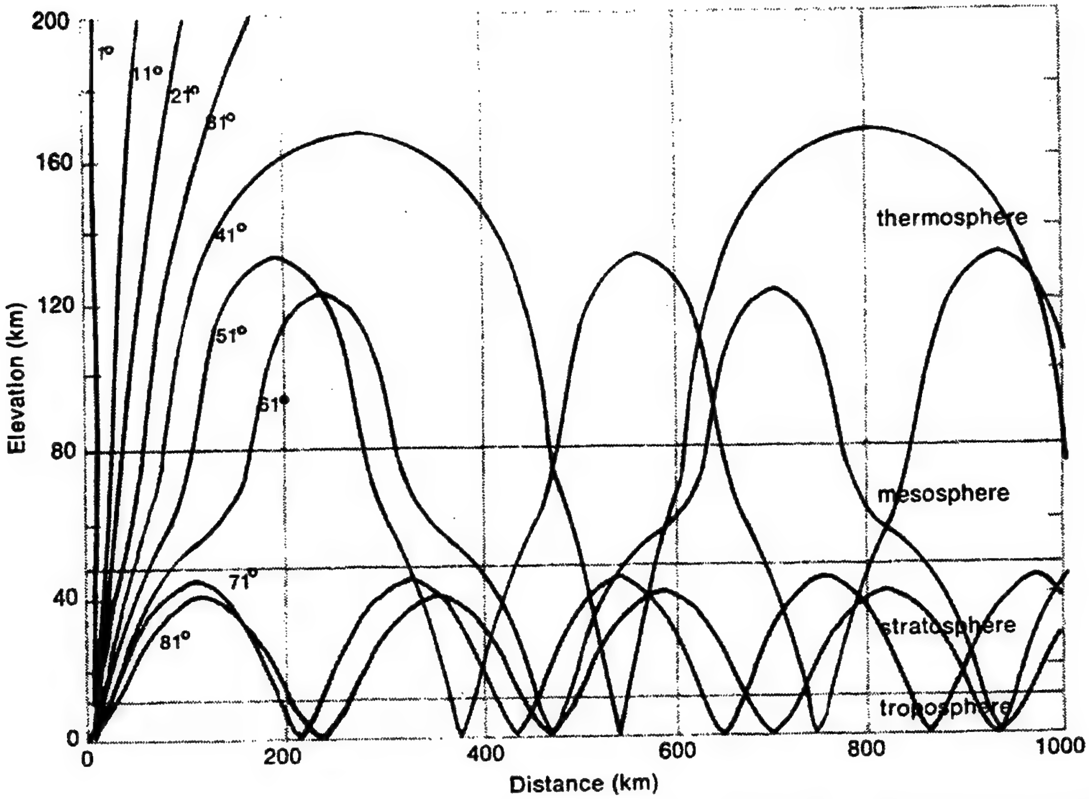

Figure 4. Ray paths for a sound source on the ground to a range of 1000 km including both stratospheric and ionospheric reflections. [Figure adopted from *Donn* (1978).]

Eq. (1.5) implies that it is the component of the wind velocity in the direction of propagation which contributes to the effective sound speed. The transverse component of the wind is also important for atmospheric propagation as it produces horizontal refraction which contributes to significant uncertainty in bearing estimates from arrays of acoustic or infrasonic sensors (microbarographs) [e.g., *Georges and Beasley* (1977)].

For purposes of infrasonic monitoring, it is important to know and to characterize the variability of sound speed, as controlled by temperature and wind speed, as functions of season and hemispheric location. Such a characterization is made possible in an average sense through the existence of a data set referred to as the COSPAR (Committee on Space Research) International Reference Atmosphere: 1986 (0 km to 120 km). The data set is available from NASA's National Space Science Data Center and includes only the lower part (0 km to 120 km) of CIRA (COSPAR International Reference Atmosphere)-86. The latter consists of tables of the monthly mean values of temperature and zonal wind for the

latitude range 80^{o}S to 80^{o}N. Two files exist, one in pressure coordinates, including also the geopotential heights, and one in height coordinates, including pressure values.

Figures 5 through 12 provide the zonally averaged CIRA-86 temperature profiles as a function of season (January, April, July and October), of atmospheric height in 5 km intervals, and as a function of latitude in the range extending from 80^{o}S to 80^{o}N for both the northern and southern hemispheres.

Inspection of the figures shows, first of all, that the profiles are essentially form invariant and that, for a given season and hemisphere, the primary variation in the temperature profiles is caused by changes in latitude which affect the locations of the tropopause, stratopause and mesopause. In addition, the location of the stratopause is almost always at an altitude of 50 km.

In January, the depth of the mesopause is seen to be approximately 10 km lower in the southern hemisphere, than in the northern hemisphere (Figures 5 and 6). In the southern hemisphere the temperature of the mesopause increases by some 50^{o}K as the equator is approached from 80^{o}S whereas in the northern hemisphere the temperature of the mesopause increases by some 20^{o} as 80^{o}N is approached from the equator. The variability in the temperature of the stratopause does not appear to be as linear with change in latitude as is the case for the mesopause. In the southern hemisphere, the zonally averaged temperature of the tropopause decreases some 32^{o}K from 232.5^{o}K to 199.8^{o}K as the equator is approached from 80^{o}N. In the northern hemisphere, the temperature of the tropopause increases from the equator with increasing latitude until 60^{o}N, beyond which the temperature of the tropopause decreases with increasing latitude.

Figures 7 and 8 compare northern and southern hemisphere temperature profiles for the month of April. The structures of the profiles are quite similar and there is far less latitudinal variability as was in evidence for the January profiles. In the northern hemisphere, there is more latitudinal variability in mesospheric temperature than in the

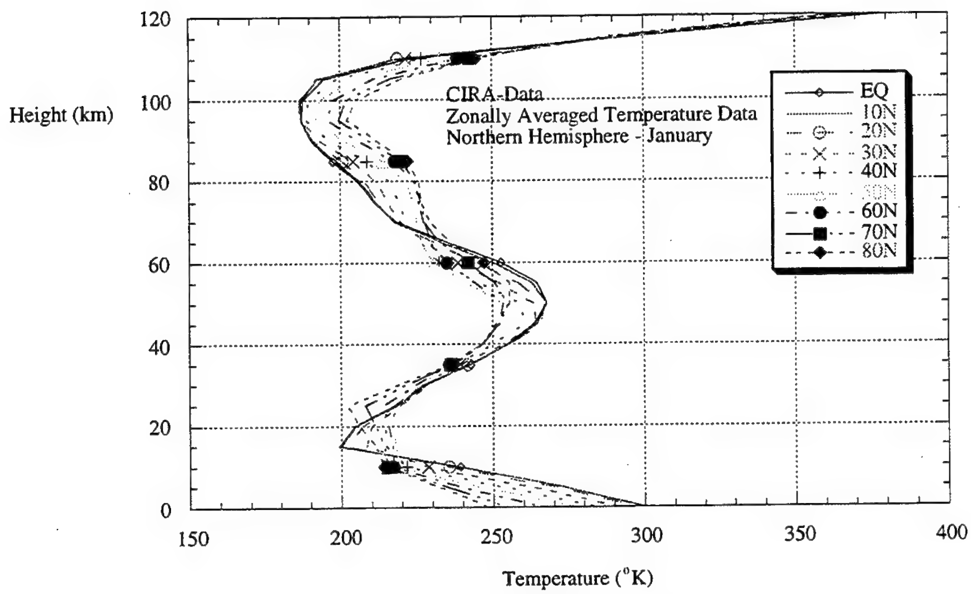

Figure 5. Zonally averaged temperature data as a function of height during the month of January for the northern hemisphere. [Figure constructed based on the CIRA-86 data set.]

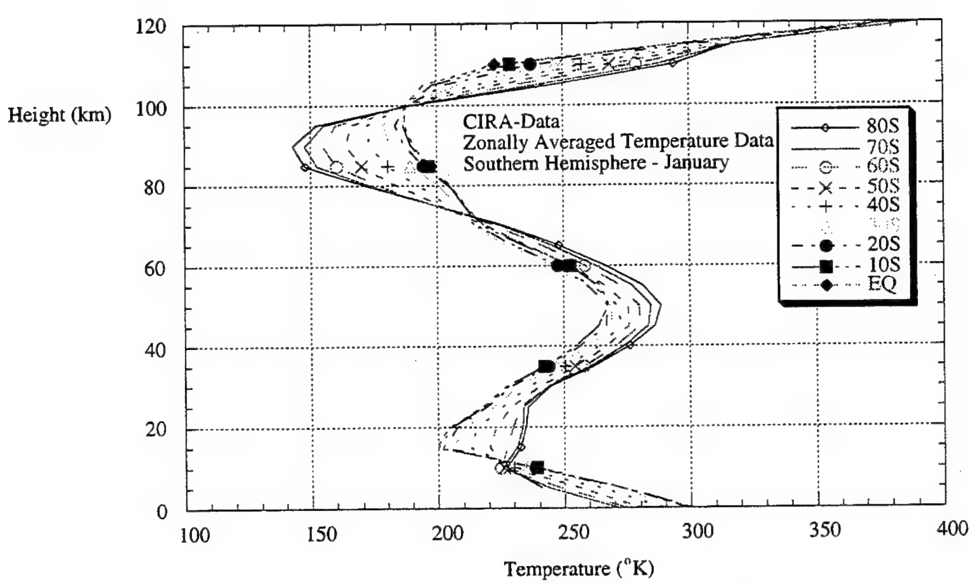

Figure 6. Zonally averaged temperature data as a function of height during the month of January for the southern hemisphere. [Figure constructed based on the CIRA-86 data set.]

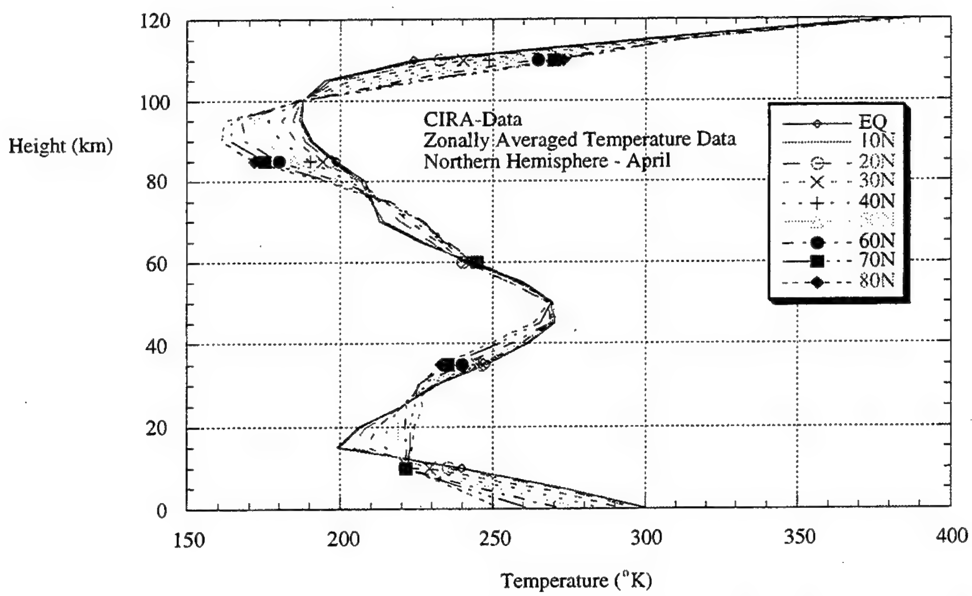

Figure 7. Zonally averaged temperature data as a function of height during the month of April for the northern hemisphere. [Figure constructed based on the CIRA-86 data set.]

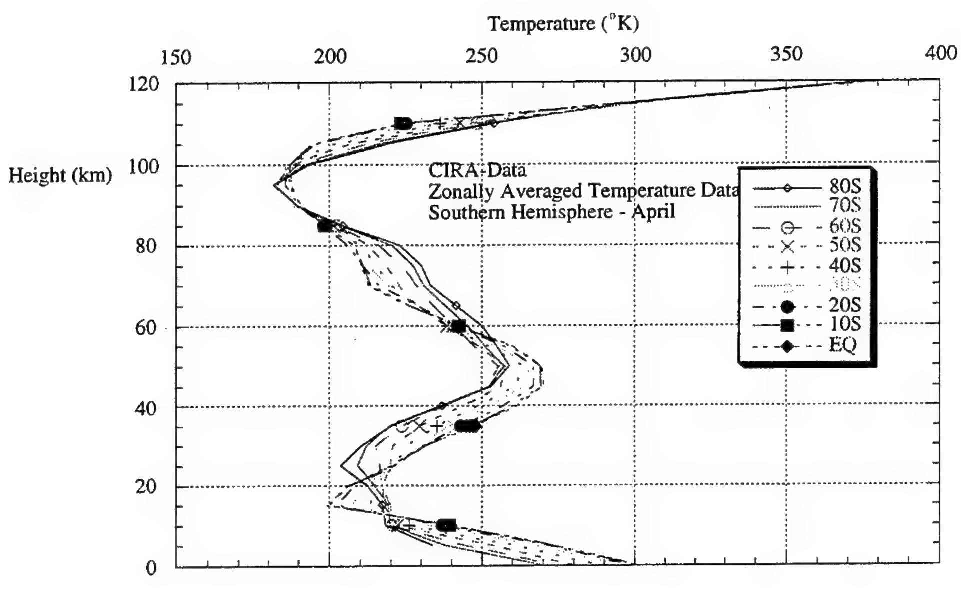

Figure 8. Zonally averaged temperature data as a function of height during the month of April for the southern hemisphere. [Figure constructed based on the CIRA-86 data set.]

southern hemisphere, whereas there is more latitudinal variability in the temperature of the stratopause in the southern hemisphere than in the northern hemisphere.

Figures 9 and 10 compare northern and southern hemisphere temperature profiles for the month of July. The northern hemisphere exhibits more variability in mesopause and stratopause temperatures than does the southern hemisphere. However, the opposite is true for tropopause temperatures in the southern hemisphere. The mesopause temperature decreases as the equator is approached from 80^oS in the southern hemisphere and decreases with increasing latitude in the northern hemisphere. In the northern hemisphere, the temperature of the stratopause increases non-monotonically from 265^oK at the equator to 284.5^oK at 80^oN. In the southern hemisphere, the temperature of the tropopause increases from 80^oS to 40^oS and then decreases with decreasing longitude until the equator is reached. In the northern hemisphere, the temperature of the tropopause increases monotonically from 202^oK to 231^oK as the latitude increases from the equator to 80^oN.

Finally, Figures 11 and 12 compare northern and southern hemisphere profiles for the month of October. The southern hemisphere exhibits more latitudinal variability in the temperature of the mesopause than does the northern hemisphere, whereas the reverse is true for the temperature of the stratopause if one neglects the southern hemisphere data at 70^oS and at 80^oS. In the southern hemisphere, the mesopause temperature increases monotonically from 162.4^oK at 80^oS to 190.1^oK at the equator. In the northern hemisphere, there is no general trend of stratopause temperature with latitude.

Given the somewhat detailed presentation of atmospheric temperature data, it may be helpful to the general reader to present the temperature data in a summarized form as has been done in Figure 13 which displays a meridional cross section of zonally averaged temperatures (in ^oC) for the northern and southern hemispheres.

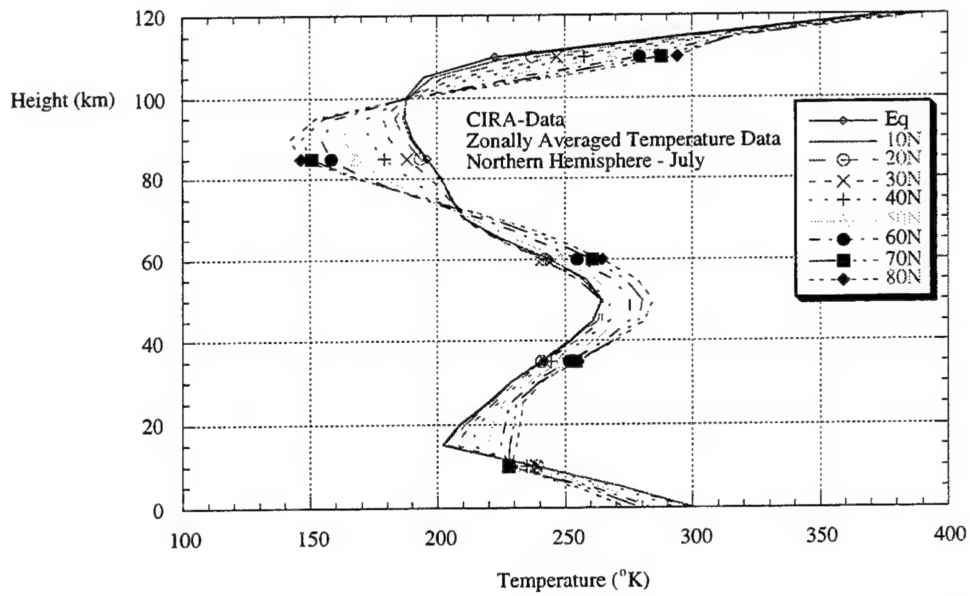

Figure 9. Zonally averaged temperature data as a function of height during the month of July for the northern hemisphere. [Figure constructed based on the CIRA-86 data set.]

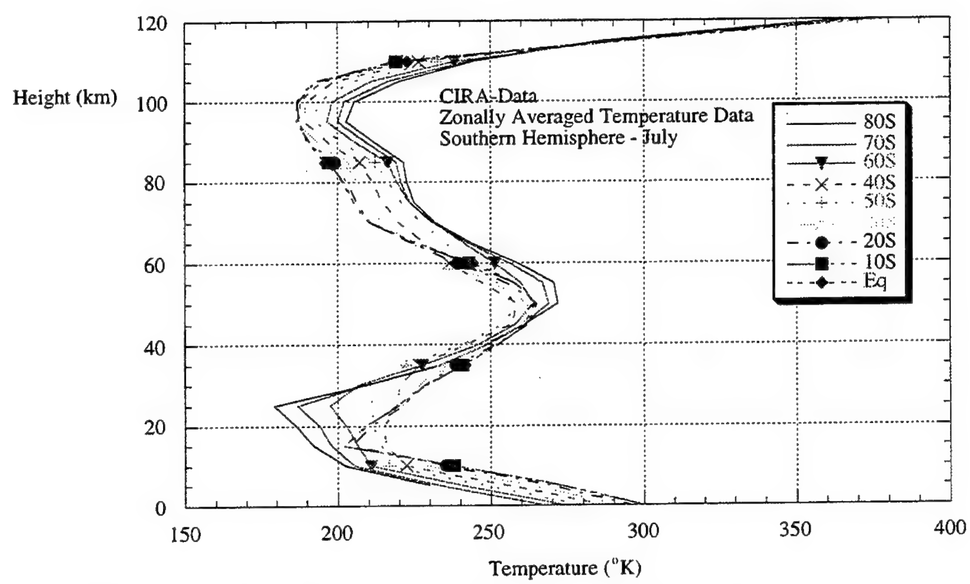

Figure 10. Zonally averaged temperature data as a function of height during the month of July for the southern hemisphere. [Figure constructed based on the CIRA-86 data set.]

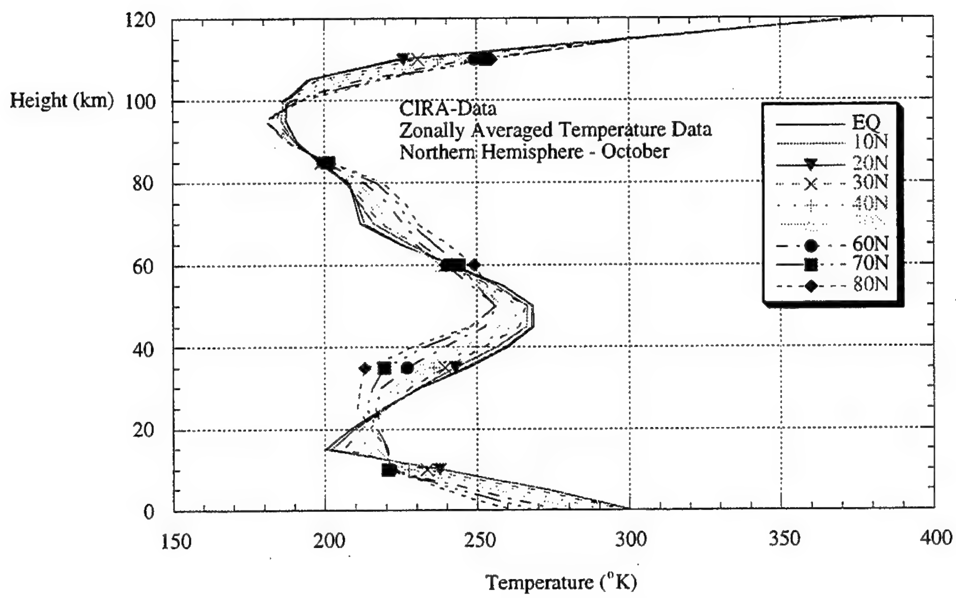

Figure 11. Zonally averaged temperature data as a function of height during the month of October for the northern hemisphere. [Figure constructed based on the CIRA-86 data set.]

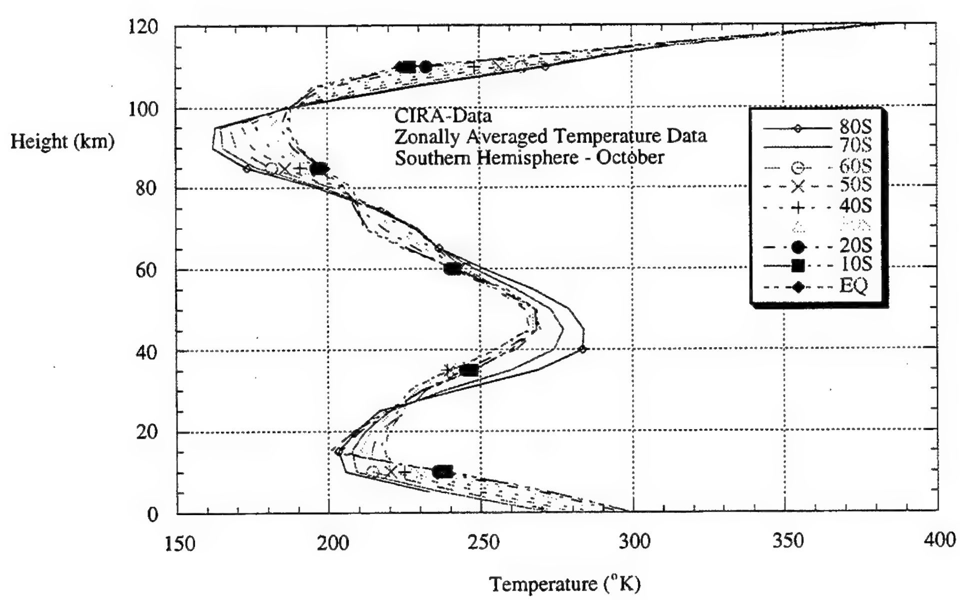

Figure 12. Zonally averaged temperature data as a function of height during the month of October for the southern hemisphere. [Figure constructed based on the CIRA-86 data set.]

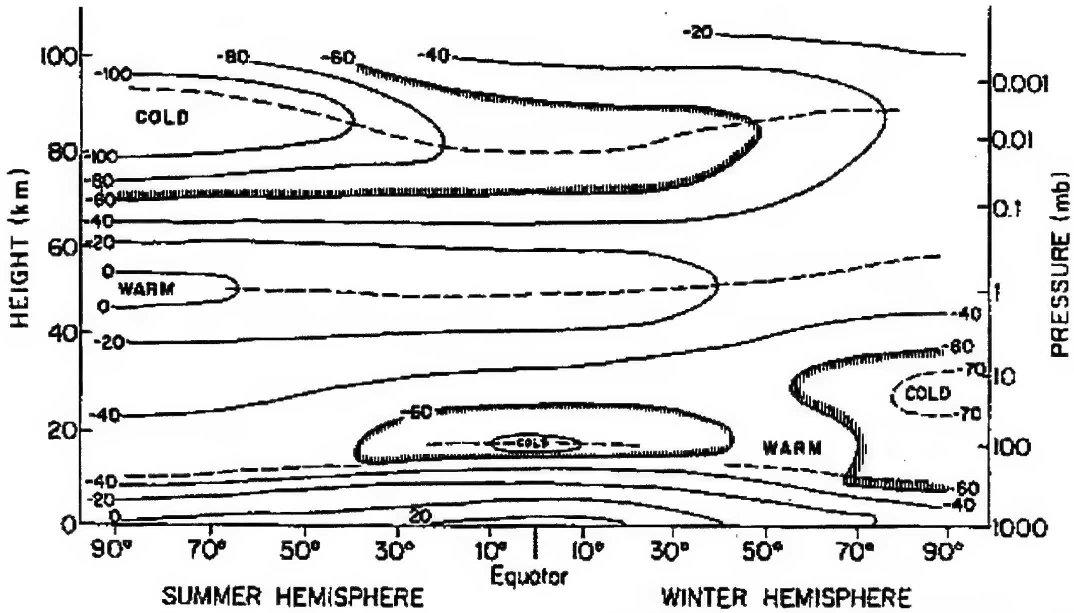

Figure 13. Meridional cross section of longitudinally averaged temperature in degrees Celcius at the time of the solstices. Dashed lines indicate tropopause, stratopause, and mesopause. [Figure adopted from *Wallace and Hobbs* (1977).]

The wind speed data from the CIRA-86 database is presented in Figures 14 through 21 which provide information on the seasonal variability of wind speed in the northern and southern hemispheres. Positive values of wind speed correspond to winds blowing from west-to-east ("westerly winds"), and negative values of wind speed correspond to winds blowing from east-to-west ("easterly winds"). Inspection of the figures clearly illustrates that wind speed exhibits significantly higher variability than does temperature, that the profiles are characterized by significant wind shear and that quite often the magnitude of the wind speed can be an appreciable fraction of the sound speed.

Figures 14 and 15 compare the January latitudinal variation of wind speed for the northern and southern hemispheres. In both hemispheres the tropospheric winds tend to be westerly. The stratospheric winds in the northern hemisphere are quite variable in both magnitude and direction as the latitude changes from the equator to more northern latitudes. In the southern hemisphere, the stratospheric winds are seen to be easterly, less variable with latitude than those in the northern hemisphere but of a magnitude which is a significant

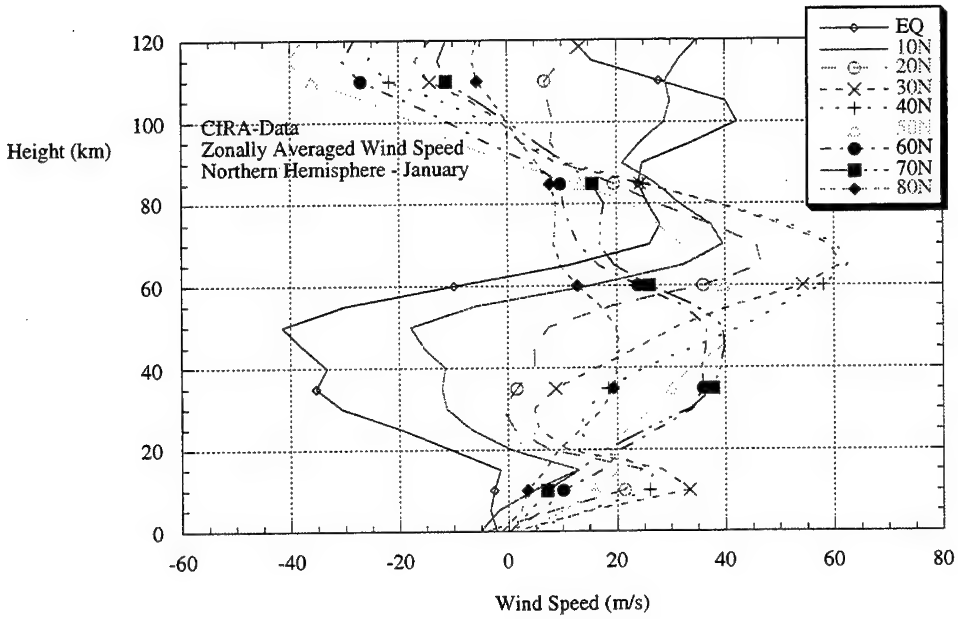

Figure 14. Zonally averaged wind speed as a function of height during the month of January for the northern hemisphere. [Figure constructed based on the CIRA-86 data set.]

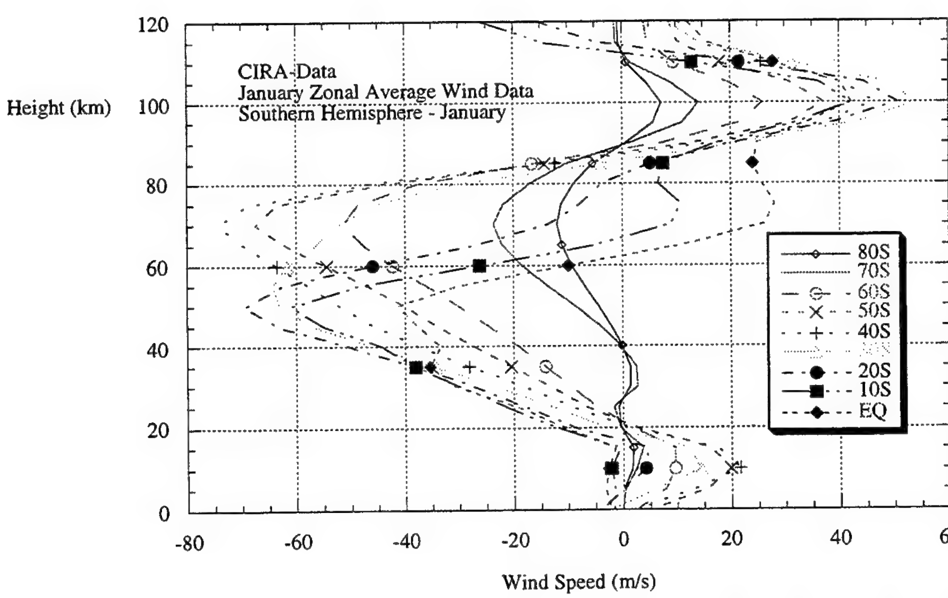

Figure 15. Zonally averaged wind speed as a function of height during the month of January for the southern hemisphere. [Figure constructed based on the CIRA-86 data set.]

fraction of the sound speed. For example, at 80^{o}S and at a stratospheric altitude of 50 km, the magnitude of the wind speed is 69.5 m/s and that of the sound speed is 329 m/s so that $|v| = 0.21$ c. The winds above 80 km are seen to be generally of opposite directions and of the same magnitudes in the two hemispheres except in the northern hemispheric region extending from the equator to 20^{o}N. Figures 16 and 17 compare April zonally averaged wind speed data for the northern and southern hemispheres where the significanly greater variability and magnitude of the winds in the southern hemisphere is evident. In both hemispheres, the tropospheric winds tend to be westerly and of about the same magnitude and both regions exhibit significant shear for stratospheric winds. For example, in the southern hemisphere the wind at an altitude of 30 km is easterly and of magnitude 20 m/s. At an altitude of 50 km, the wind is westerly and of about the same magnitude. The winds above 80 km tend to be westerly in both hemispheres.

Figures 18 and 19 compare July zonally averaged wind speed data for the northern and southern hemispheres and show that the southern hemisphere winds are of significantly greater variability than those of the north. In the northern hemisphere, the stratospheric winds in the altitude range extending from 20 km to 40 km are consistently easterly whereas in the southern hemisphere the winds are predominantly westerly except at the equator and 10^{o}S. The winds above 80 km exhibit significant wind shear above 80 km in both hemispheres.

Finally, Figures 20 and 21 compare October zonally averaged wind speed data for the two hemispheres and show that the winds in both hemispheres are quite variable. The winds above 80 km and in the troposphere are generally westerly and there is significant shear in the stratospheric and mesospheric winds in both hemispheres.

As a way of summarizing the differences and similarities in the northern and southern hemispheric wind speed fields, Figure 22 provides a latitude-height cross section of longitudinally averaged zonal wind at the time of the solstices. As is evident from the

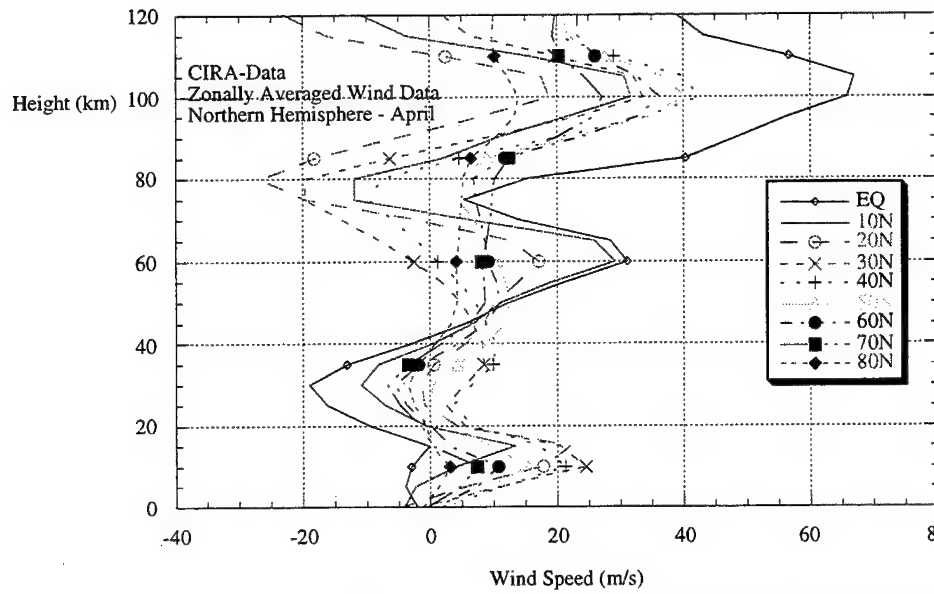

Figure 16. Zonally averaged wind speed as a function of height during the month of April for the northern hemisphere. [Figure constructed based on the CIRA-86 data set.]

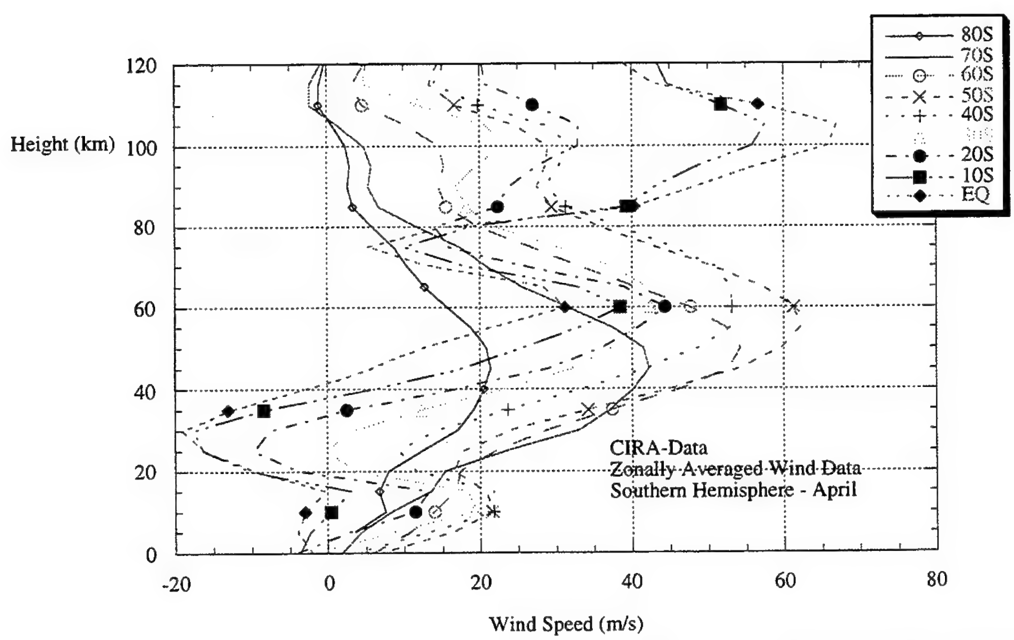

Figure 17. Zonally averaged wind speed as a function of height during the month of April for the southern hemisphere. [Figure constructed based on the CIRA-86 data set.]

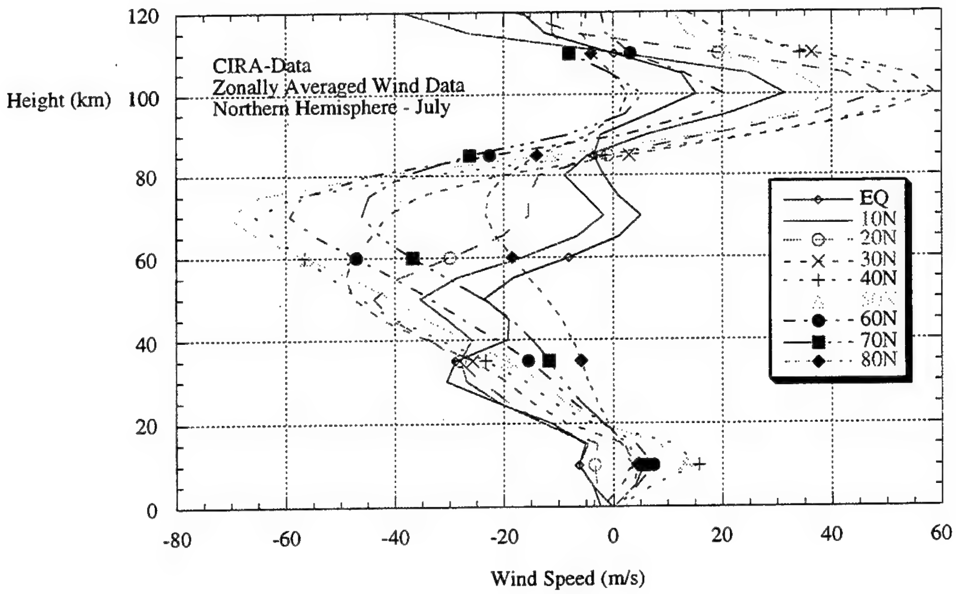

Figure 18. Zonally averaged wind speed as a function of height during the month of July for the northern hemisphere. [Figure constructed based on the CIRA-86 data set.]

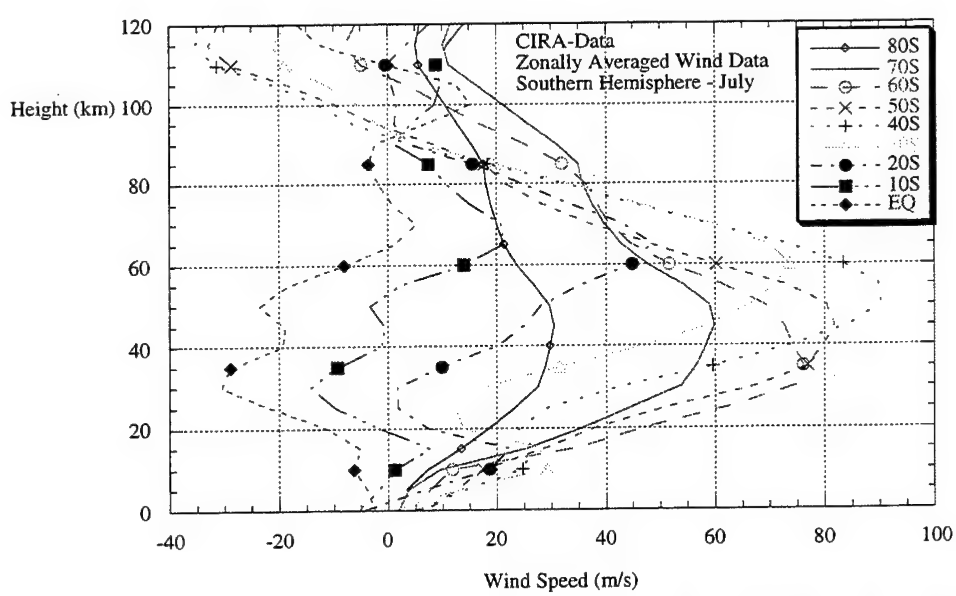

Figure 19. Zonally averaged wind speed as a function of height during the month of July for the southern hemisphere. [Figure constructed based on the CIRA-86 data set.]

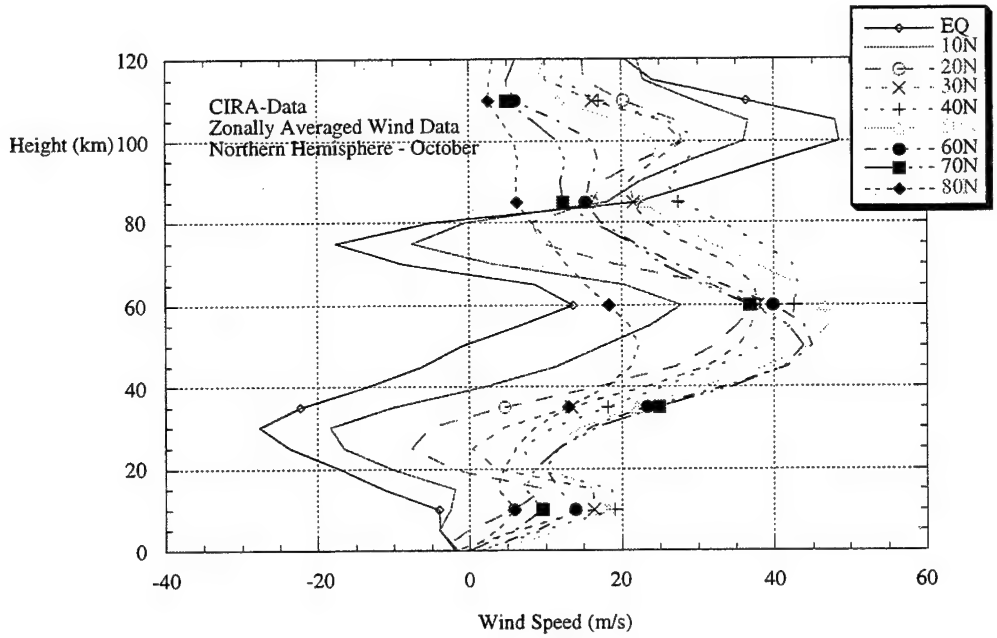

Figure 20. Zonally averaged wind speed as a function of height during the month of October for the northern hemisphere. [Figure constructed based on the CIRA-86 data set.]

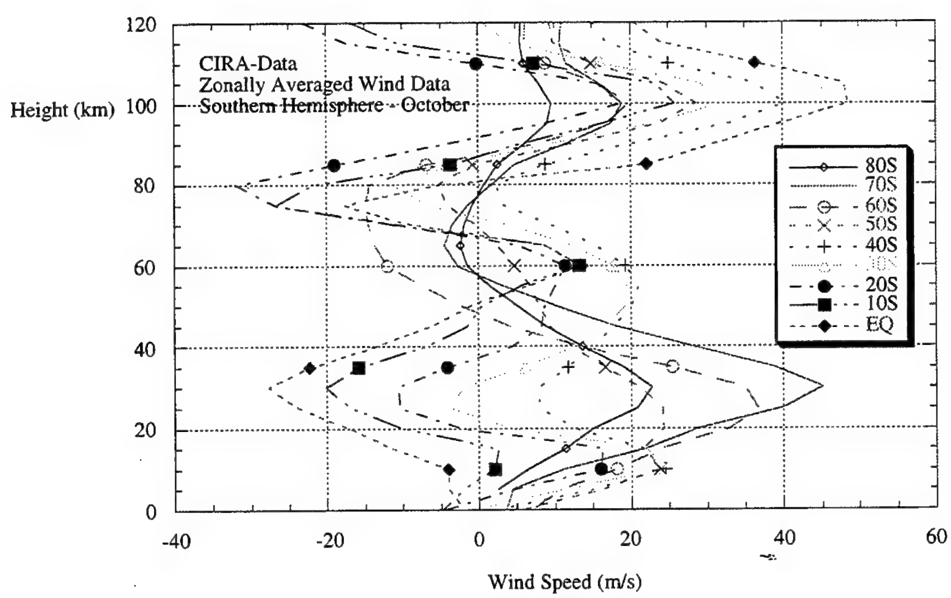

Figure 21. Zonally averaged wind speed as a function of height during the month of October for the southern hemisphere. [Figure constructed based on the CIRA-86 data set.]

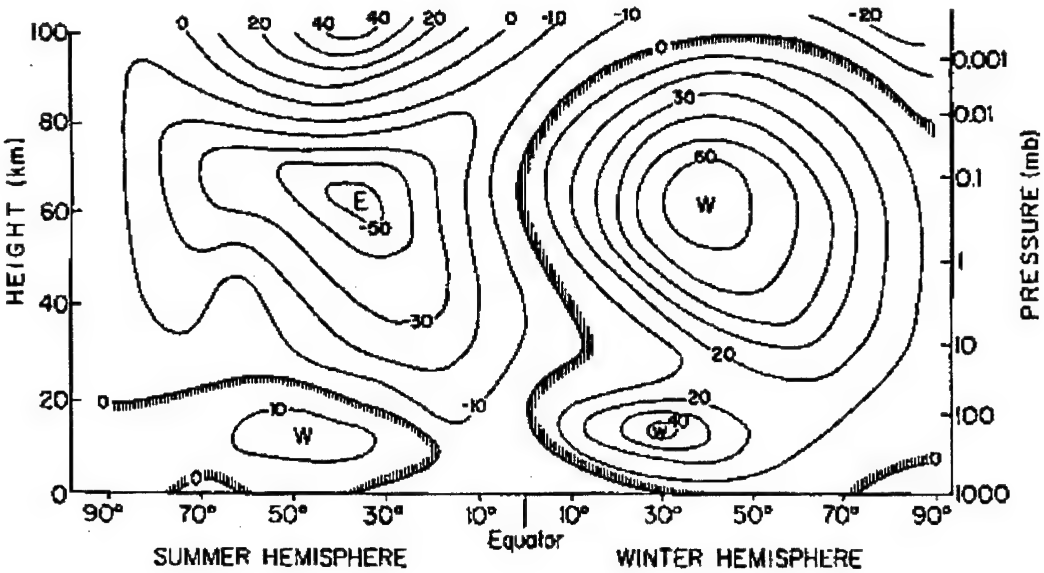

Figure 22. A meridional cross section of longitudinally averaged zonal wind in meters per second at the time of the solstices. [Figure adopted from *Wallace and Hobbs* (1977).]

figure, the strongest winds are the mesospheric jets which propagate to the west (easterly winds) in the summer hemisphere and to the east (westerly winds) in the winter hemisphere. It is evident that there are also concentrated wind jets in the troposphere both of which are westerly and that these winds are about four times higher than those in the summer hemisphere.

Wind influences propagation in the atmosphere primarily by its effect on the sound speed profile and the effects are strongly dependent on whether the propagation is "upwind" or "downwind". In the stratosphere and mesosphere, the magnitude of the wind velocity can be a significant fraction of the sound speed magnitude.

To illustrate the importance of wind in determining the effective sound speed, as defined by Eq. (1.5), and to contrast the differences between the northern and southern hemispheres, Figures 23 through 34 present a comparison of zonally averaged sound speed, wind speed and effective sound speed profiles. Profiles are presented for two latitudes: 40°N and 40°S; and for four seasons: January, April, July and October.

Figure 23 compares the sound speed profiles, as determined by temperature alone for the month of January. The profiles are quite similar, particularly in the troposphere. The temperature in the southern hemisphere is evidently higher in the stratosphere and lower in

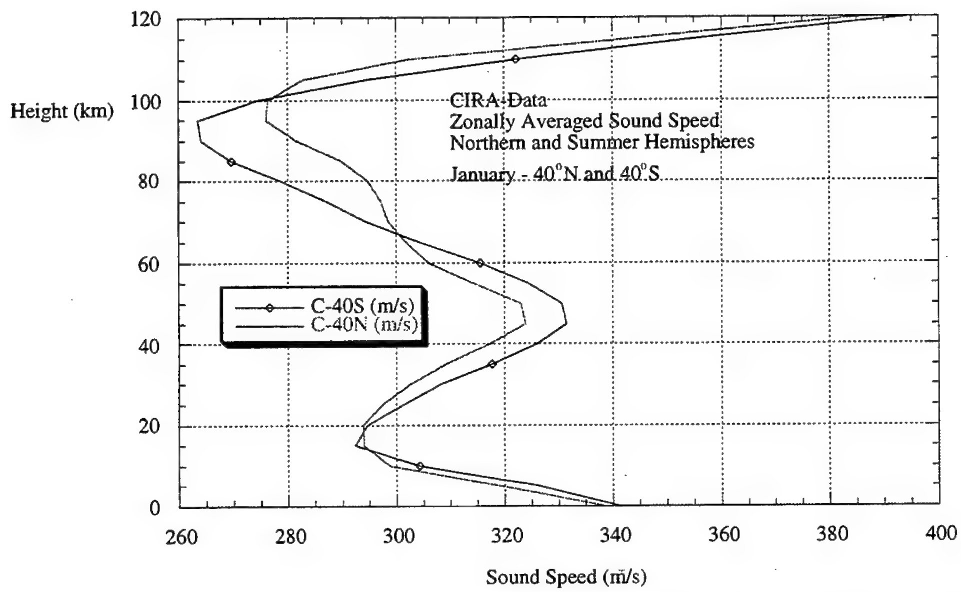

Figure 23. Zonally averaged sound speed as a function of height at 40^{O}N and 40^{O}S for the month of January.

the mesosphere than in the northern hemisphere, as mirrored in the sound speed profiles. The profiles also exhibit the usual stratospheric and mesospheric upper atmosphere ducts.

Figures 24 and 25 present similar data for wind speed and effective sound speed as a function of altitude. The strong mesospheric jets illustrated previously in Figure 21 are clearly in evidence with westerly mesospheric winds in the northern hemisphere and easterly winds in the southern hemisphere. Tropospheric winds are quite similar at the two latitudes below the level of the tropopause.

Figure 25 presents the effective sound speed as computed by Eq. (1.5) using the speed as computed by Eq. (1.5) using the data in Figures 23 and 24. Inspection of Figure 25 and comparison with Figure 23 forcefully demonstrates the influence of the wind when directed west-to-east (upwind or UPW) and when directed east-to-west (downwind or

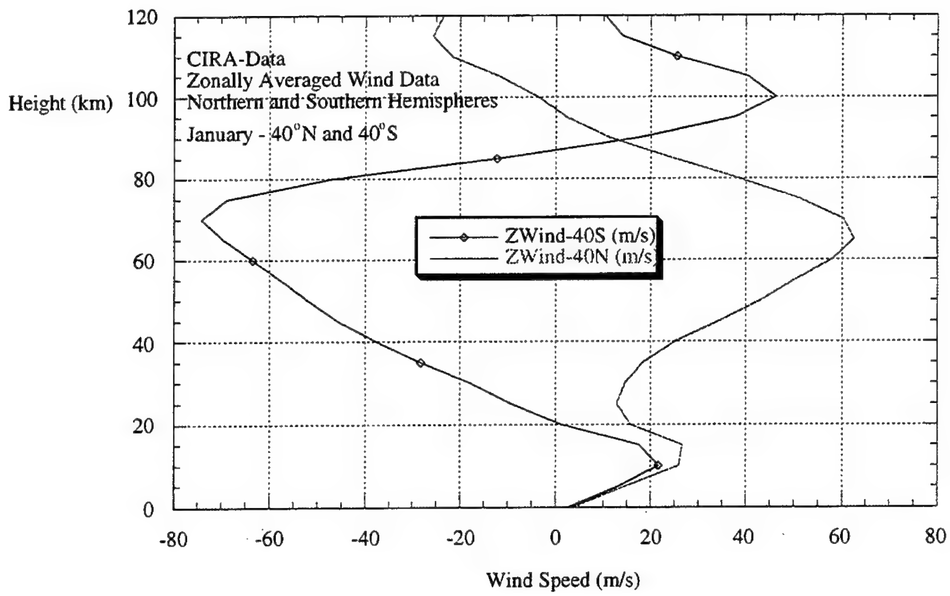

Figure 24. Zonally averaged wind speed as a function of altitude for latitudes 40°N and 40°S for the month of January.

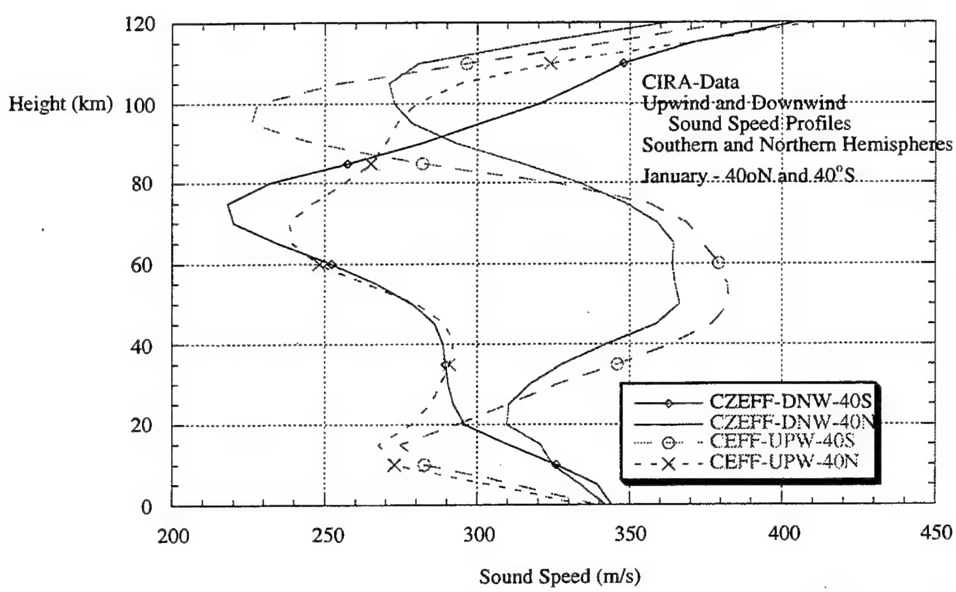

Figure 25. Zonally averaged effective sound speed as a function of altitude for latitudes 40°N and 40°S for the month of January.

DWN) in determining the effective sound speed profiles. Indeed, the downwind profile (CZEFF-DNW-40^{o}S) has been extensively modified and no longer displays the "canonical" double duct structure.

Figure 26 compares the sound speed profiles, as determined by temperature alone, for the month of April and for latitudes 40^{o}N and 40^{o}S, and the profiles are observed to be almost identical. The wind speed profiles, as exhibited in Figure 27, are seen, however, to be quite different at all levels above about 30 km and virtually identical below the tropopause. The very strong mesospheric jets are again in evidence with the direction to the east at the southern latitude and to the west in the northern latitude.

The resultant effective sound speed profiles are compared in Figure 28 and are found to be extensively modified: particularly so for the UPW-40S and UPW-40N profiles although the profiles are virtually the same in the troposphere and thermosphere. The DNW-40S and UPW-40N retain the typical double duct structure, are virtually identical in the troposphere, but differ significantly from each other up to altitudes of 100 km.

Figure 29 compares the temperature dependent sound speed profiles for the month of July and it is evident that the tropospheric components are almost identical. The stratosphere is warmer at the northern latitude than at the southern altitude and the reverse is true for the mesosphere. Figure 30 compares the July zonally averaged wind speed profiles for the two latitudes and the very pronounced mesospheric jets are in evidence with westwardly propagation in the southern hemisphere and easterly propagation in the northern hemisphere. There are slight differences between the profiles in the troposphere, but significant differences in the thermosphere.

Figure 31 compares the upwind and downwind July effective sound speed profiles and the differences between these and those in Figure 29 are clearly significant. Indeed, the DWN-40N and UPW-40S profiles exhibit only a single mesospheric sound speed duct rather than the more typical stratospheric and mesospheric ducts. The DWN-40S and

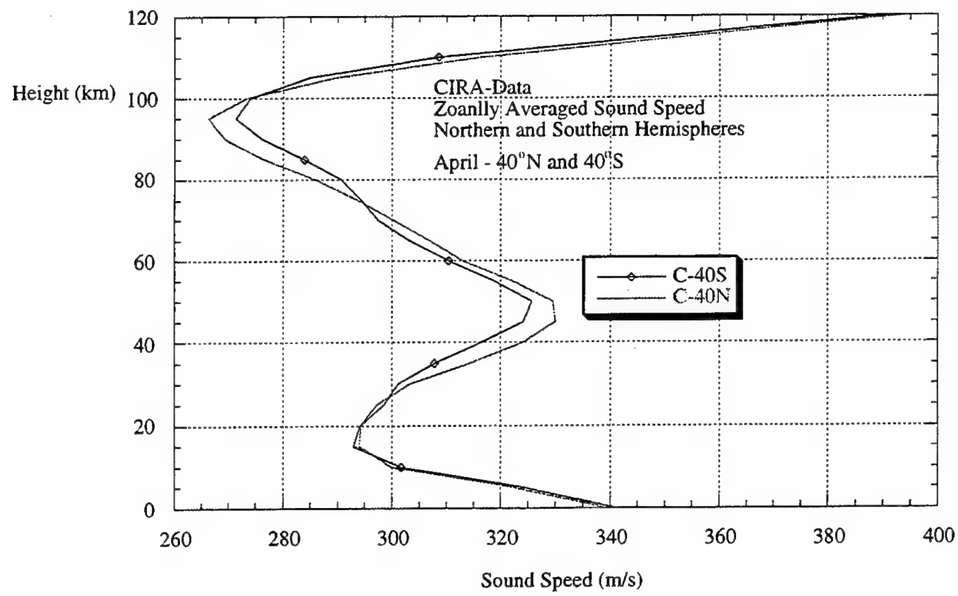

Figure 26. Zonally averaged sound speed as a function of altitude for latitudes 40°N and 40°S for the month of April.

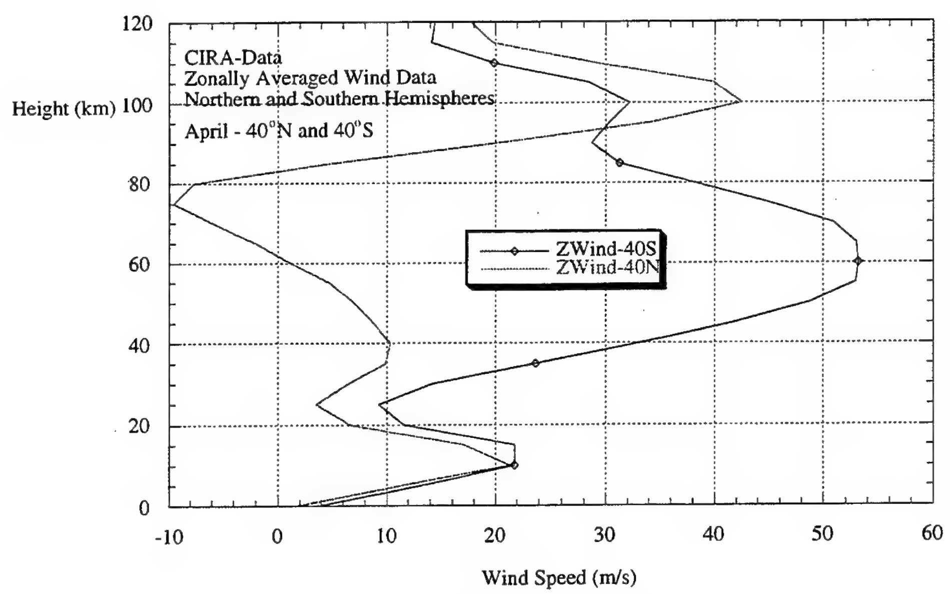

Figure 27. Zonally averaged wind speed as a function of altitude for latitudes 40°N and 40°S for the month of April.

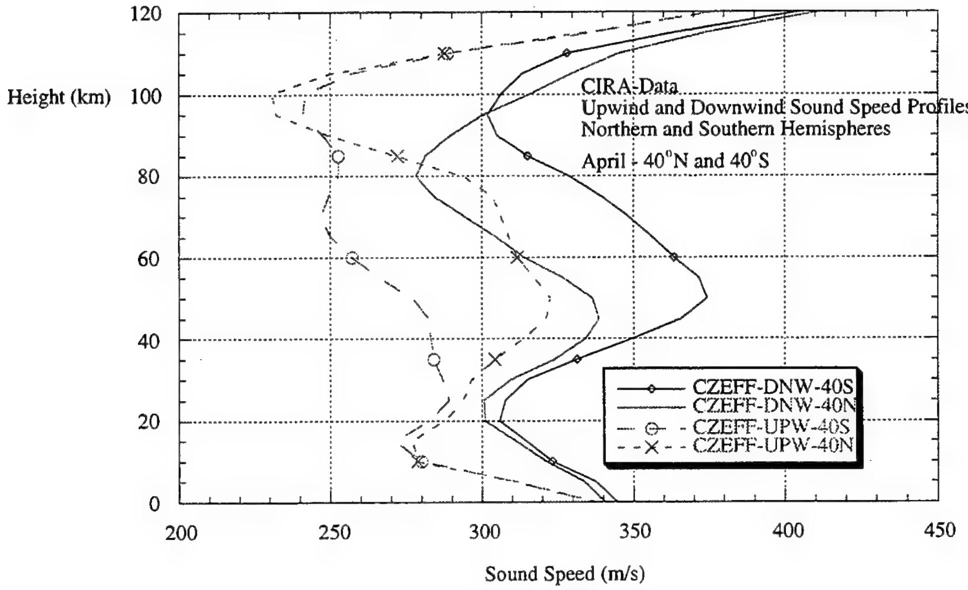

Figure 28. Zonally averaged effective sound speed as a function of altitude for latitudes 40°N and 40°S for the month of April.

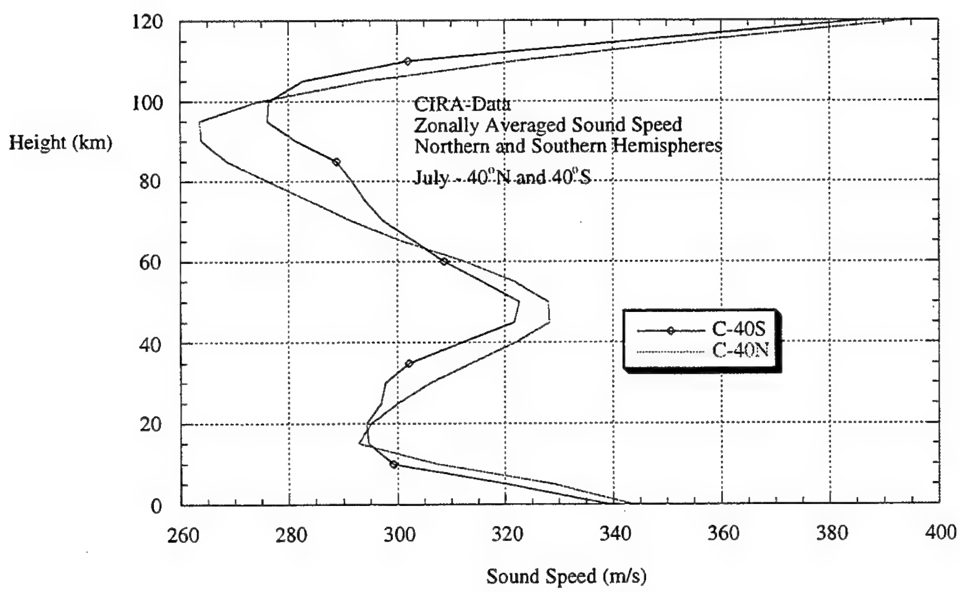

Figure 29. Zonally averaged effective sound speed as a function of altitude for latitudes 40°N and 40°S for the month of July.

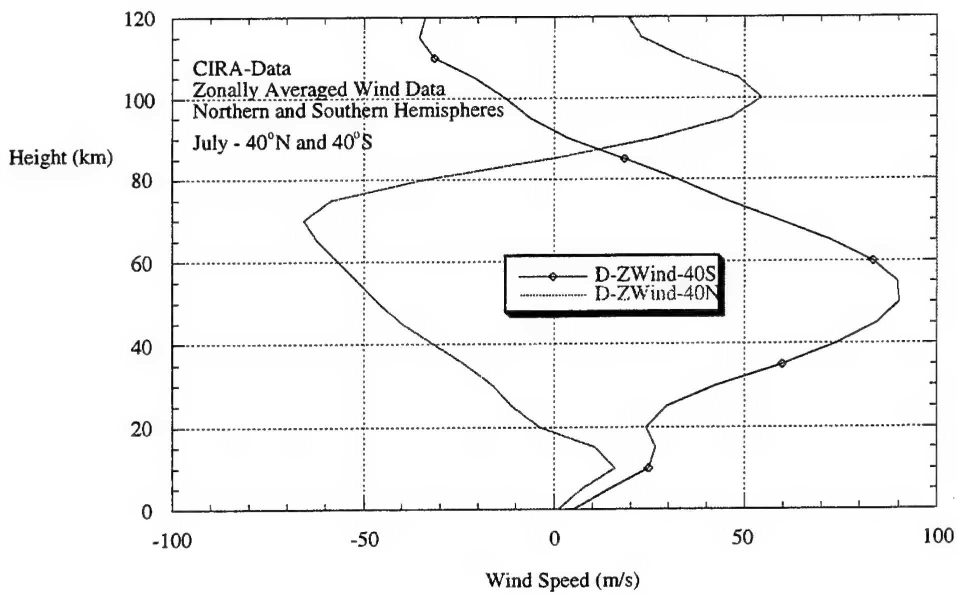

Figure 30. Zonally averaged wind speed as a function of altitude for latitudes 40°N and 40°S for the month of July.

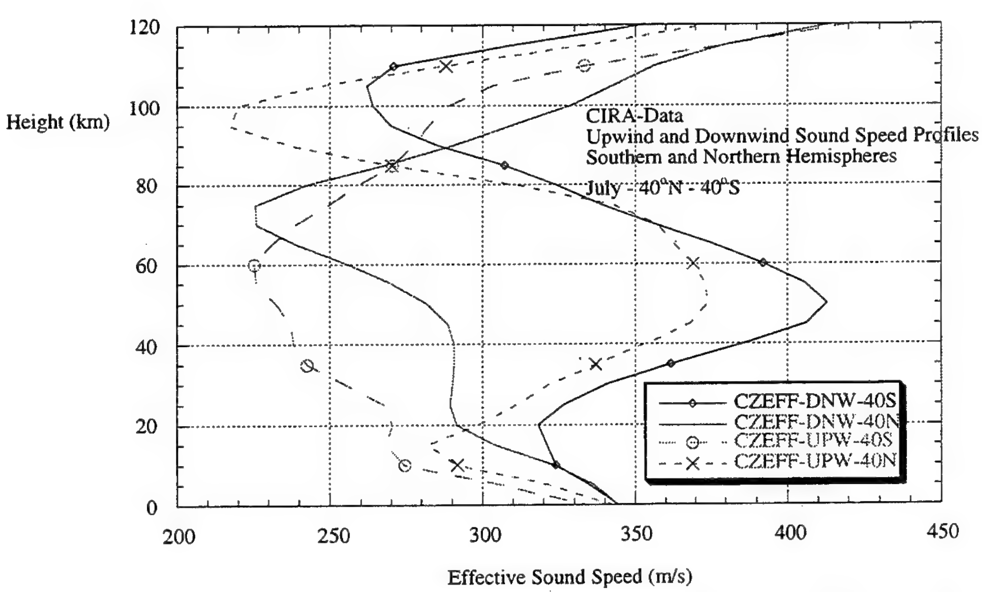

Figure 31. Zonally averaged effective sound speed as a function of altitude for latitudes 40°N and 40°S for the month of July.

UPW-40N profiles are the same in the troposphere but differ significantly at all other altitudes.

Finally, Figure 32 compares the temperature dependent sound speed profiles as a function of altitude for the month of October and the profiles are seen to be virtually identical. The wind speed profiles, shown in Figure 33 are also similar in structure at the lowest and highest altitudes, but differ significantly in the region between 30 km and 90 km. The wind direction is, however, westerly at both latitudes and at all altitudes, although the mesospheric jet is much stronger in the northern hemisphere.

The zonally averaged upwind and downwind effective sound speed profiles for the month of October are provided in Figure 34. Inspection of the figure shows that the downwind profiles at both latitudes, CZEFF-DNW-40S and CZEFF-DNW-40N, are quite similar: particularly so up to a height of 40 km. The upwind profiles are essentially the same in the troposphere and thermosphere, but differ in the intermediate altitude region extending from 25 km to 85 km.

As an example of the significant effects that winds and propagation direction can have on acoustic propagation in the atmosphere, Figure 35 provides a computer-generated plot of the very complicated behavior of acoustic ray paths for propagation in the U.S. Standard Atmosphere 1962 for a source at a height of 5 km above the earth's surface [*Georges and Young* (1972)]. In conducting the modeling, the acoustic frequency was taken to be 300 Hz and the propagation conditions are seen to be distinctly different for propagation in the downwind and upwind directions. For more realistic wind speed profiles, it is reasonable to expect an even more complicated ray path pattern and, based on the data presented above, the pattern will be a strong function of hemispheric location and season.

In addition to effecting ray paths and rendering propagation in the atmosphere anisotropic, upper atmospheric winds and propagation direction significantly influence the

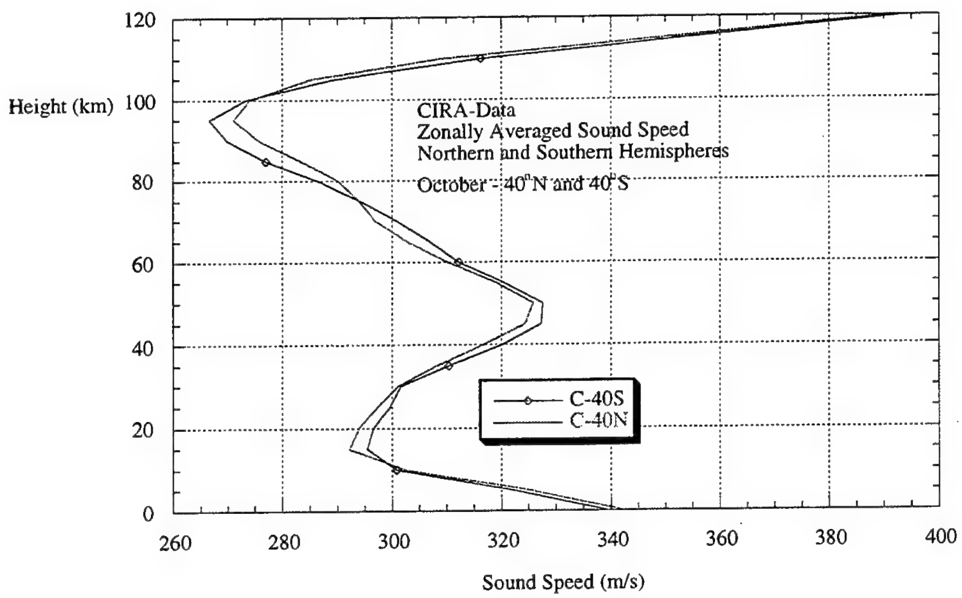

Figure 32. Zonally averaged sound speed as a function of altitude for latitudes 40ON and 40OS for the month of October.

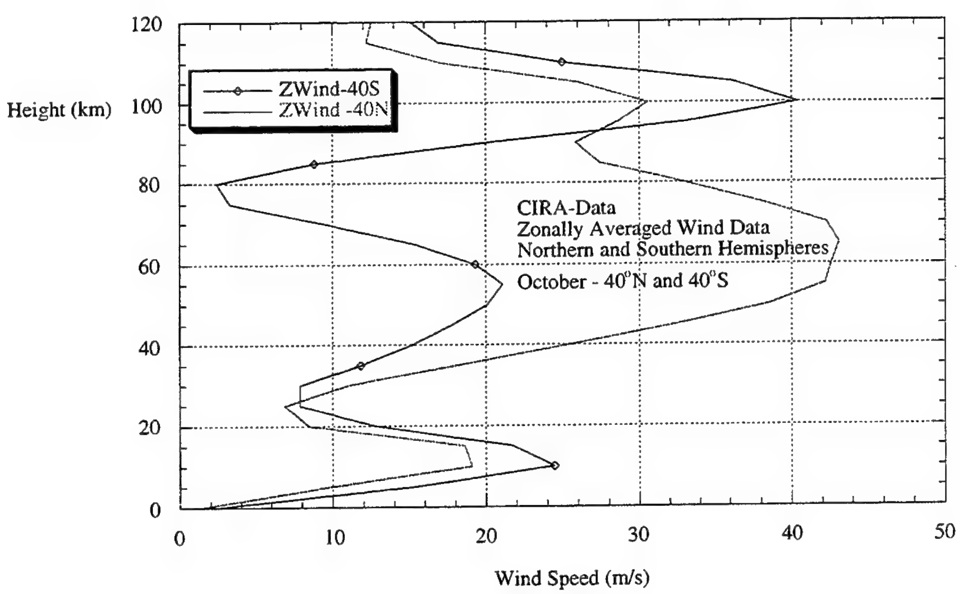

Figure 33. Zonally averaged wind speed as a function of altitude for latitudes 40ON and 40OS for the month of October.

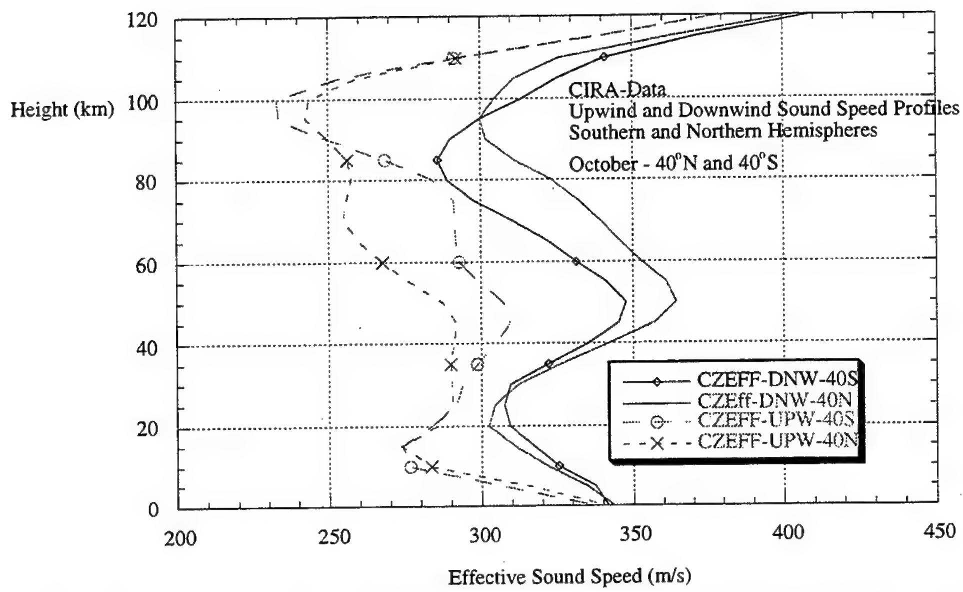

Figure 34. Zonally averaged effective sound speed as a function of altitude for latitudes 40°N and 40°S for the month of October.

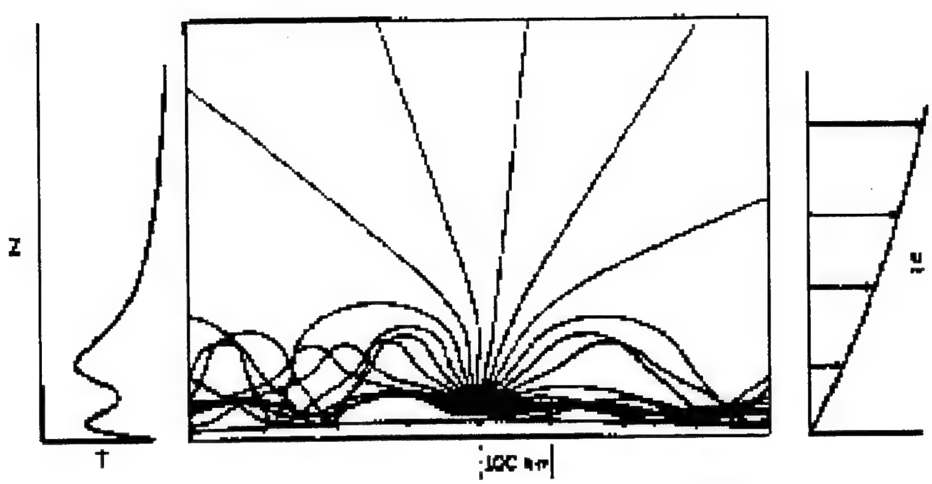

Figure 35. Acoustic ray paths for a source at 5 km altitude in the U.S. Standard Atmosphere 1962. The temperature profile is shown to the left of the central panel in the figure and the assumed logarithmic wind speed profile is indicated to the right of the central panel. [Figure adopted from *Georges and Young* (1972).]

form of the received pulse from a nuclear or chemical explosion in the atmosphere: a circumstance which is illustrated in Figure 36. The figure illustrates the synthesis of a

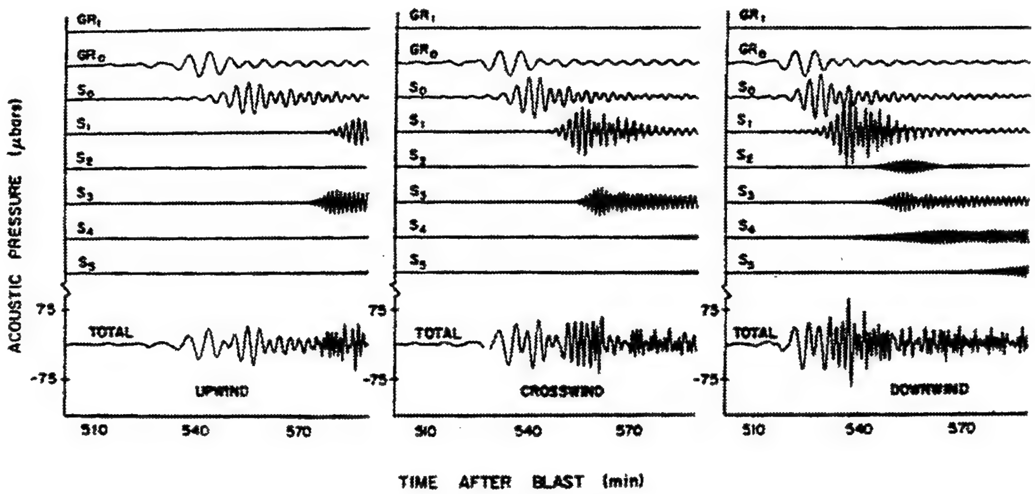

Figure 36. An illustration of pulse construction and the theoretical effect of winds on pulse dispersion as computed by a full wave propagation model for an explosive source in the atmosphere [e.g., the model of *Pierce and Kinney* (1976)]. As indicated, the first two gravity wave modes (GR_0 and GR_1) and the first six acoustic modes (S_0-to-S_6) are used in computing the waveforms. The atmospheric model used is the COSPAR 1962 standard atmosphere for a subtropical summer region. The observer is on the ground and at 10,000 km range from the explosion. Propagation upwind is seen to significantly increase the time between the low and high frequency regions of the composite waveform. [Figure adopted from *Pierce, Posey and Iliff* (1971).]

received pulse by two gravity wave modes and six acoustic modes. In addition, the effects of upwind, crosswind and downwind propagation are shown for the individual modes making up the total waveform and propagation upwind is seen to significantly increase the time between the low and high frequency regions of the composite waveform.

2.0 ATMOSPHERIC TEMPERATURE, WIND SPEED, SOUND SPEED AND EFFECTIVE SOUND SPEED DATA

As discussed in the previous section, it is important to know and to characterize the variability of sound speed, as controlled by temperature and wind speed, as functions of time and hemispheric location. One such characterization is made possible in an average sense through the existence of a data set referred to as the COSPAR or *CIRA* (1986) [(Committee on Space Research) International Reference Atmosphere: 1986 (0 km to 120 km)]. The data set is available from NASA's National Space Science Data Center and includes only the lower atmospheric altitude range extending from 0 km to 120 km of the earth's atmosphere. The basic data set consists of tables of the monthly mean values of temperature and zonally averaged wind speed for the latitude range 80^{o}S to 80^{o}N in 10 degree intervals. Two files exist, one in pressure coordinates, including also the geopotential heights, and one in height coordinates, including pressure values.

As discussed by NASA, the tables were produced by *Flemming, et al.,* (1988) from several global data compilations including ground-based and satellite (Nimbus 5, 6, 7) measurements: *Oort* (1983) and *Labitzke, et al.*, (1985). The lower part was merged with MSIS (Mass Spectrometer Incoherent Scatter)-86 data at 120 km altitude. In general, hydrostatic and thermal wind balance is maintained at all levels. The model accurately reproduces most of the characteristic features of the atmosphere, such as the equatorial wind and the general structure of the tropopause, stratopause, and mesopause.

This section contains four subsections presenting zonally averaged data which is relevant to the use of infrasound to monitor compliance with a CTBT. Some of this data was presented and discussed in Section 1.0. Subsection 2.1 presents monthly and zonally averaged temperature data for the northern and southern hemispheres in 10^{o} latitude intervals extending from 80^{o}S in the southern hemisphere to 80^{o}N in the northern hemisphere [Figures 37 through 48]. Each figure presents the data for a specific month with the upper panel presenting the data from the northern hemisphere and the lower panel

presenting data from the southern hemisphere. Subsections 2.2 and 2.3 present similar data for zonally averaged wind speed [Figures 49 through 60] and zonally averaged sound speed [Figures 61 through 72], respectively. The sound speed profiles have been computed from equation (1.4) using the *CIRA* (1986) temperature data.

Finally, Subsection 2.4 presents graphs of effective sound speed computed from the *CIRA* (1986) data for the seasonal months of January, April, July and October [Figures 73 through 79] and for latitudes corresponding to the equator, and the "complementary" latitudes 20^{o} N&S, 40^{o} N&S, and 60^{o} N&S. Each figure corresponds to a particular seasonal month and consists of four panels. Both downwind and upwind effective sound speed profiles are presented.

2.1 Zonally Averaged Temperature Profiles

The data are based on the COSPAR International Reference Atmosphere: 1986 (0 km to 120 km) Figures 37 through 48.

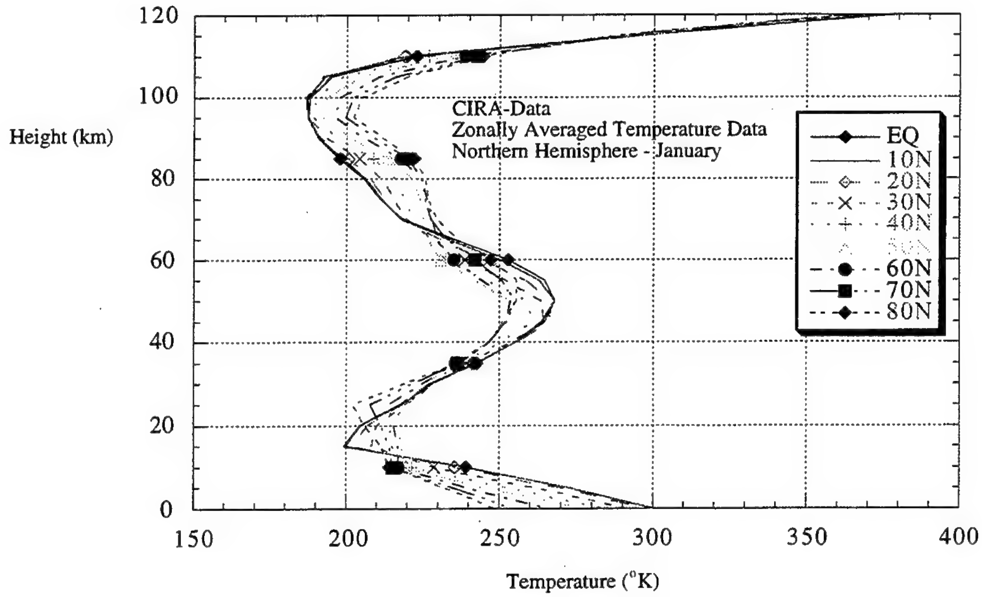

Figure 37a. Zonally averaged temperature data as a function of height during the month of January for the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

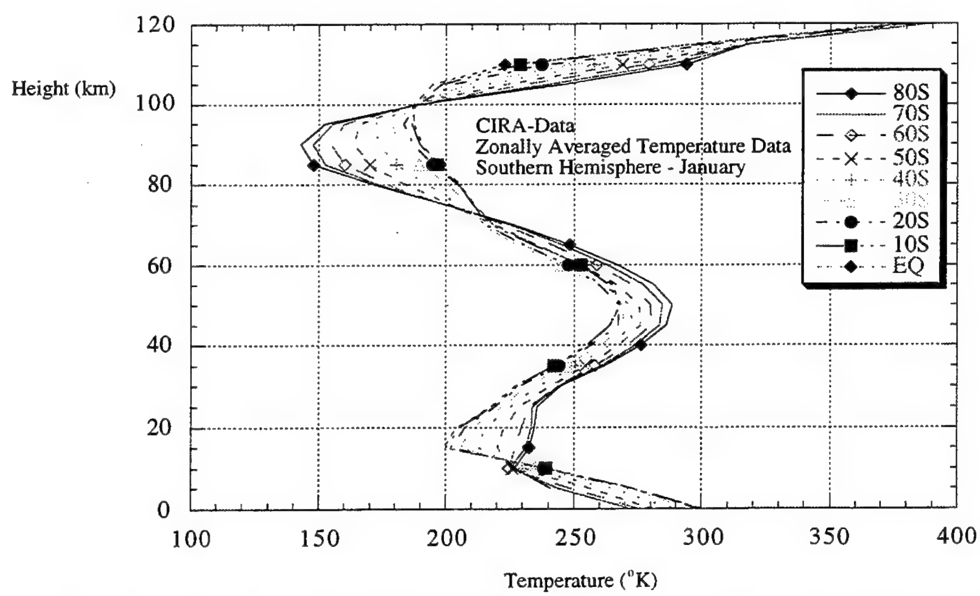

Figure 37b. Zonally averaged temperature data as a function of height during the month of January for the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

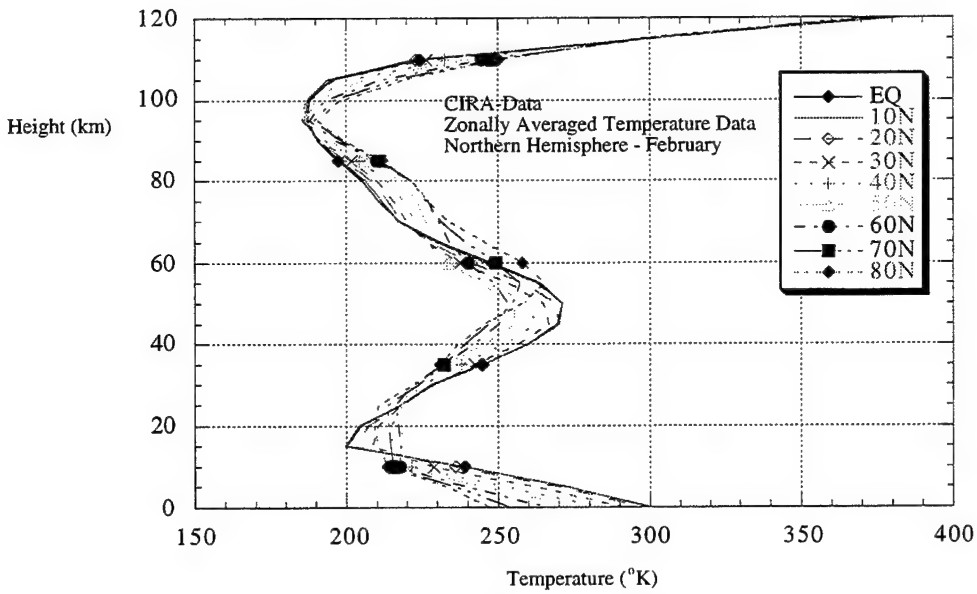

Figure 38a. Zonally averaged temperature data as a function of height during the month of February for the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

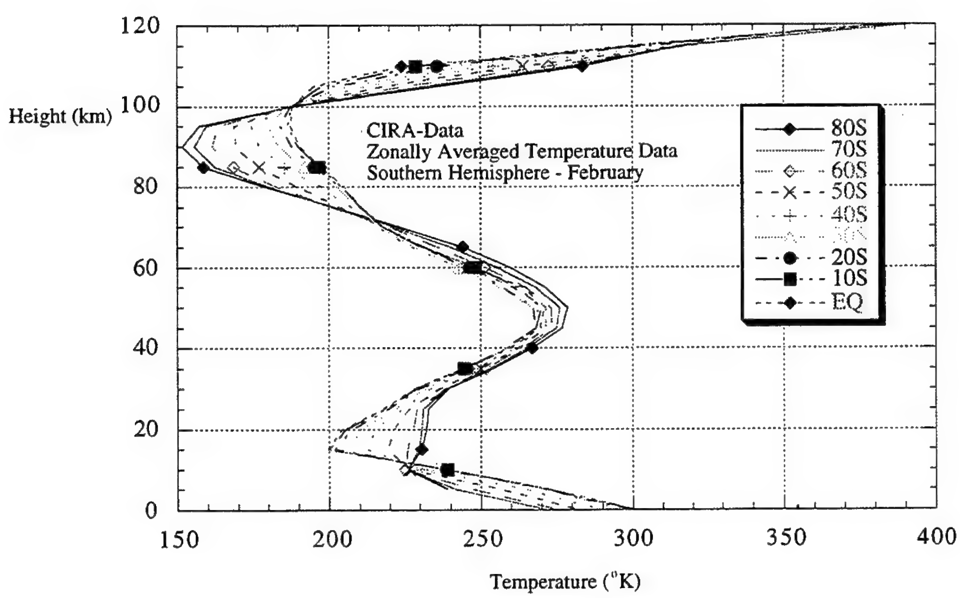

Figure 38b. Zonally averaged temperature data as a function of height during the month of February for the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

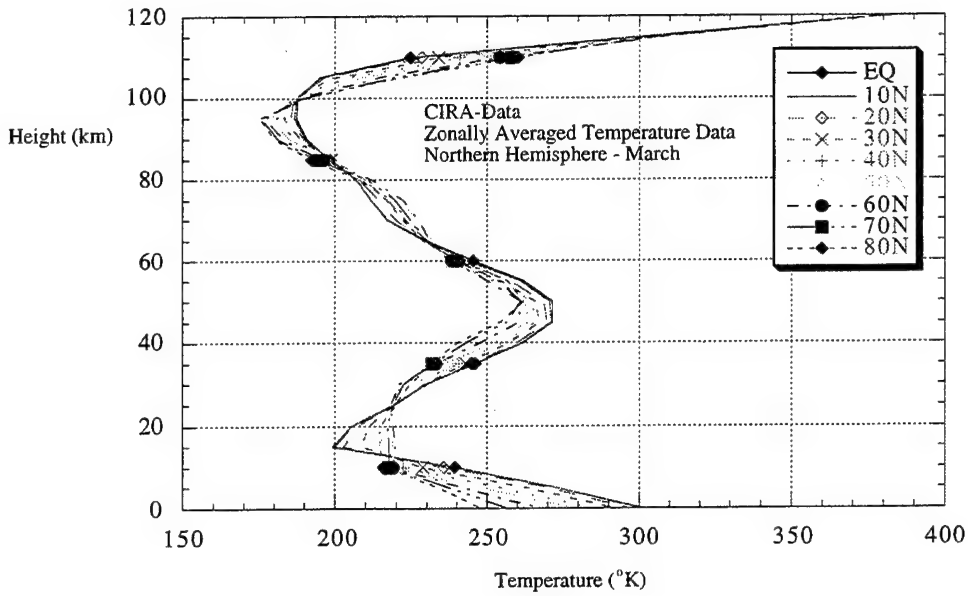

Figure 39a. Zonally averaged temperature data as a function of height during the month of March for the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

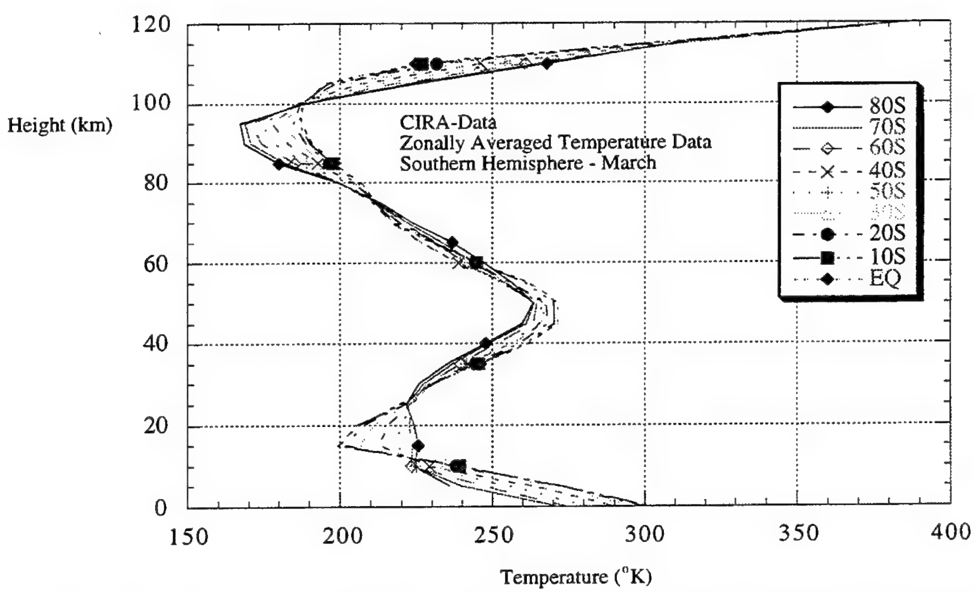

Figure 39b. Zonally averaged temperature data as a function of height during the month of March for the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

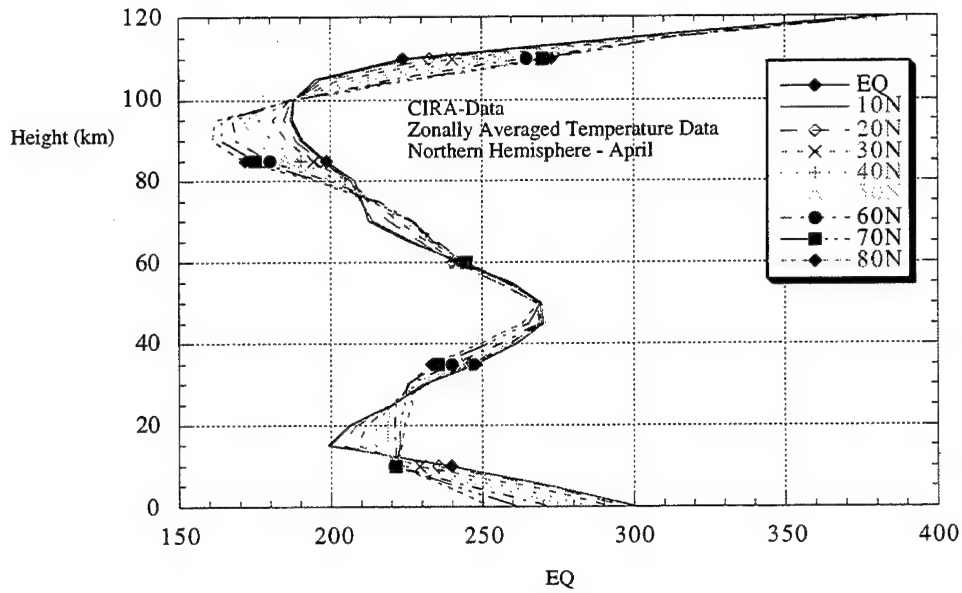

Figure 40a. Zonally averaged temperature data as a function of height during the month of April for the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

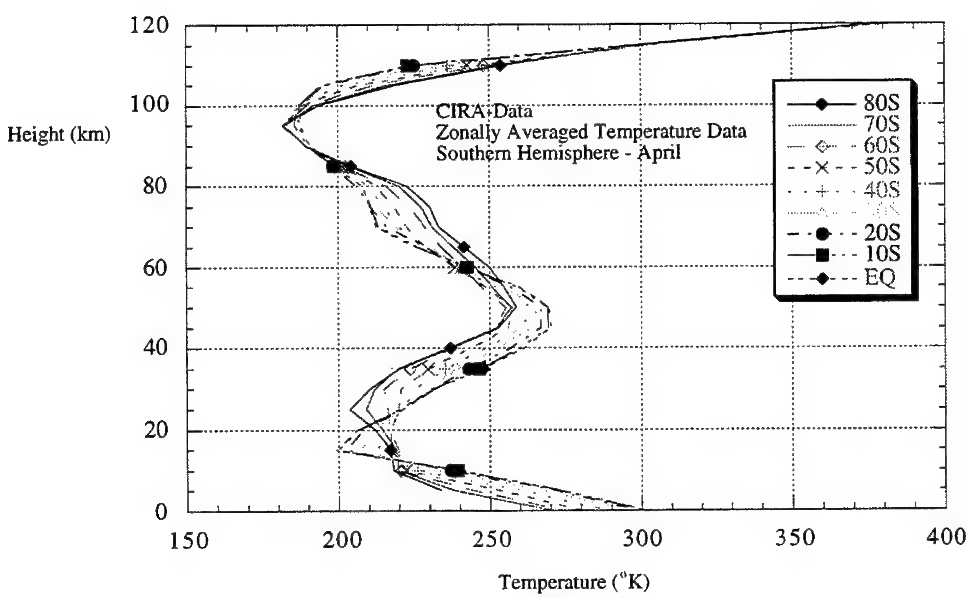

Figure 40b. Zonally averaged temperature data as a function of height during the month of April for the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

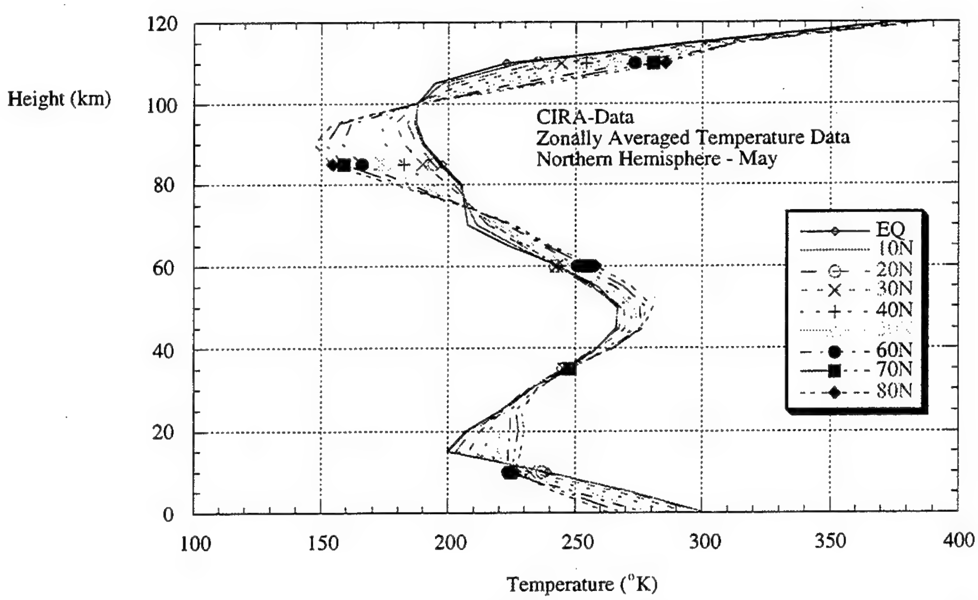

Figure 41a. Zonally averaged temperature data as a function of height during the month of May for the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

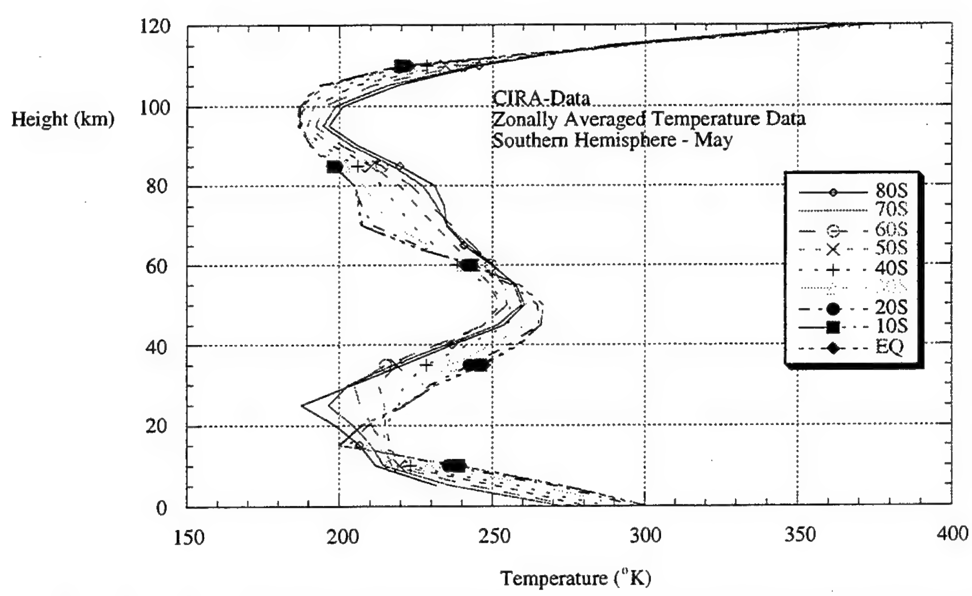

Figure 41b. Zonally averaged temperature data as a function of height during the month of May for the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

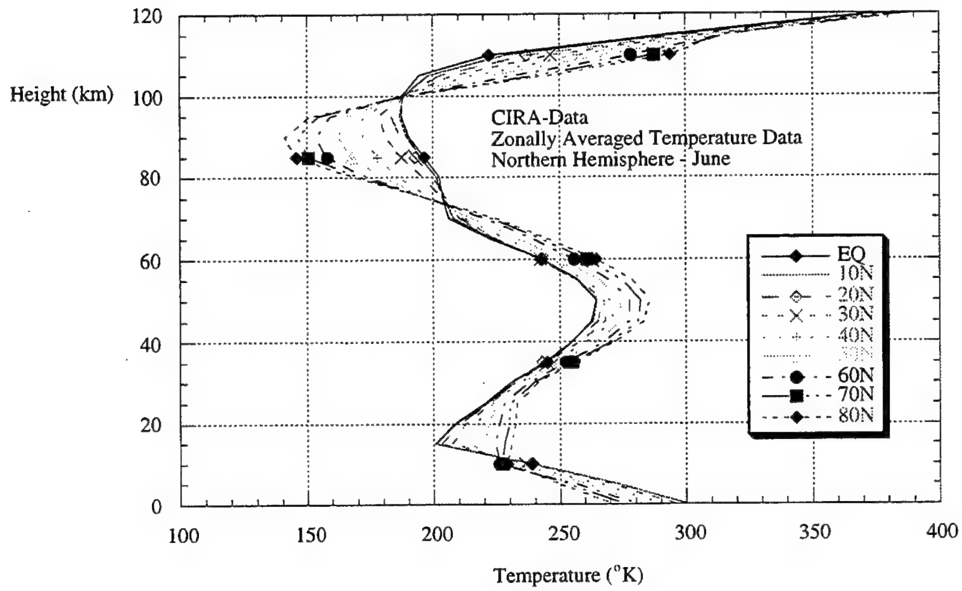

Figure 42a. Zonally averaged temperature data as a function of height during the month of June for the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

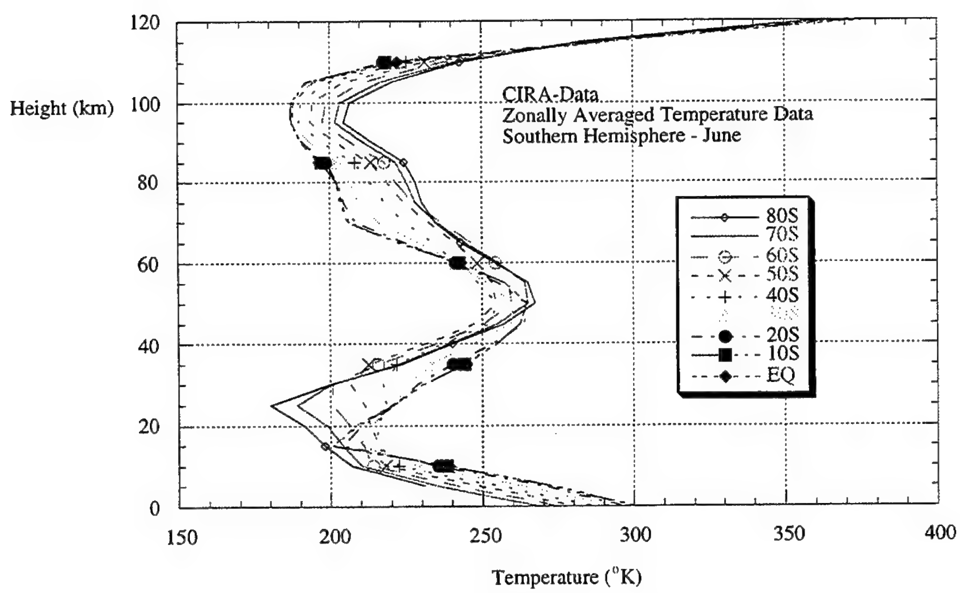

Figure 42b. Zonally averaged temperature data as a function of height during the month of June for the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

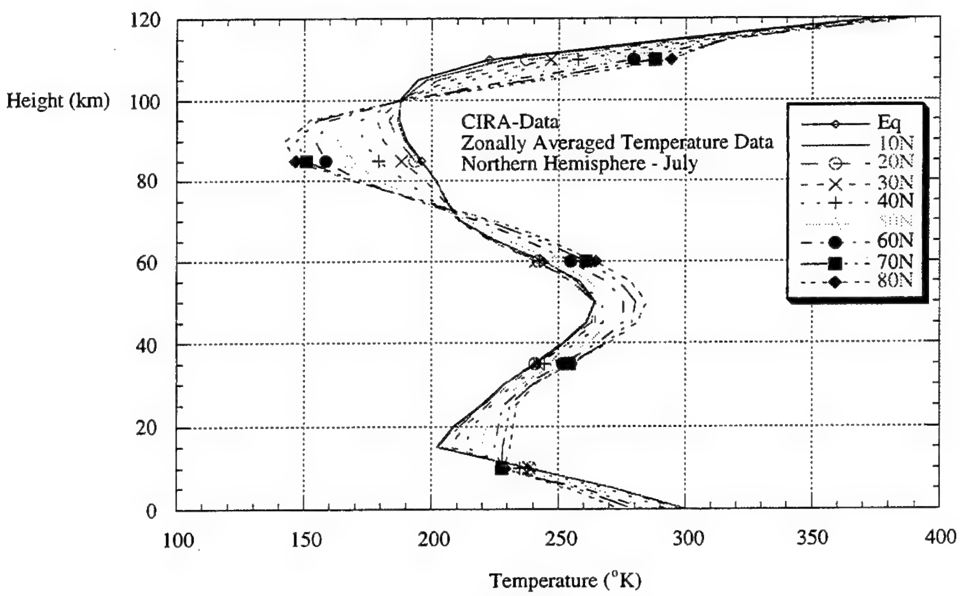

Figure 43a. Zonally averaged temperature data as a function of height during the month of July for the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

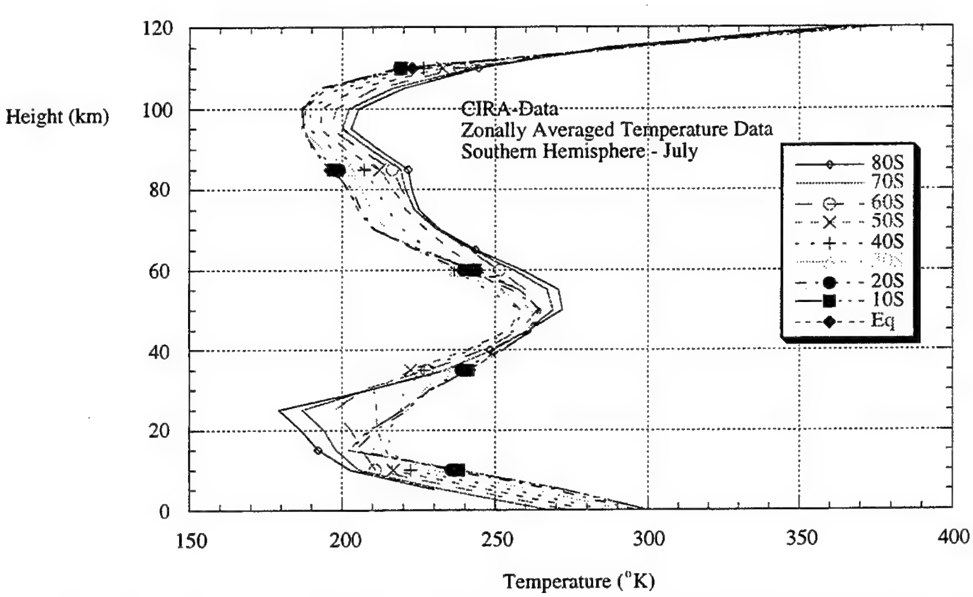

Figure 43b. Zonally averaged temperature data as a function of height during the month of July for the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

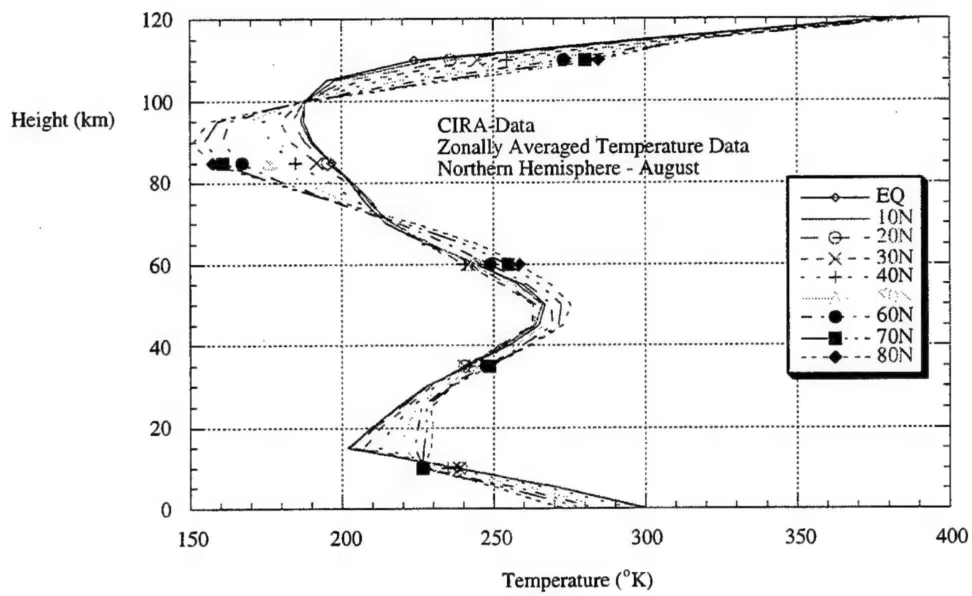

Figure 44a. Zonally averaged temperature data as a function of height during the month of August for the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

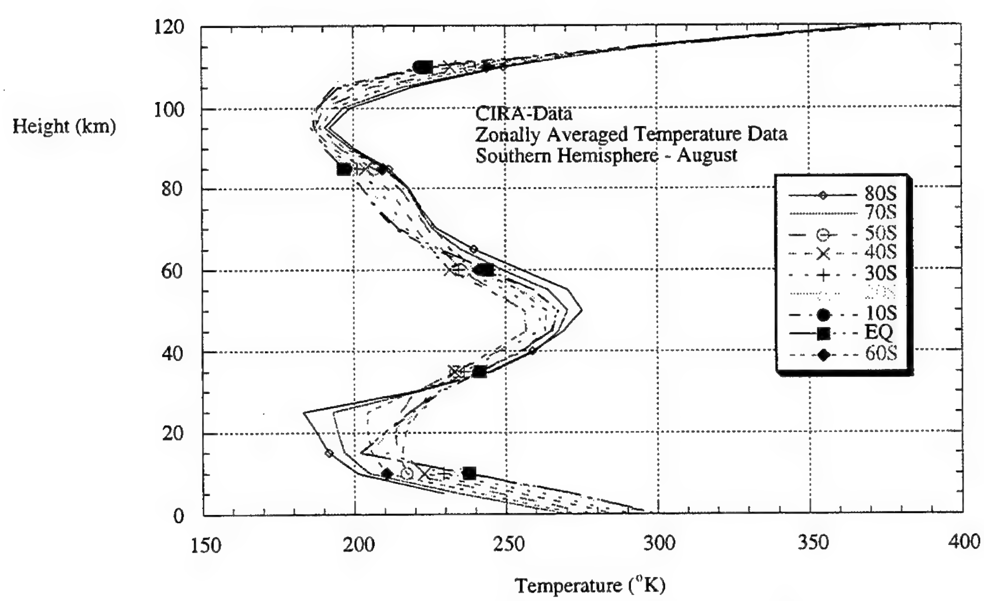

Figure 44b. Zonally averaged temperature data as a function of height during the month of August for the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

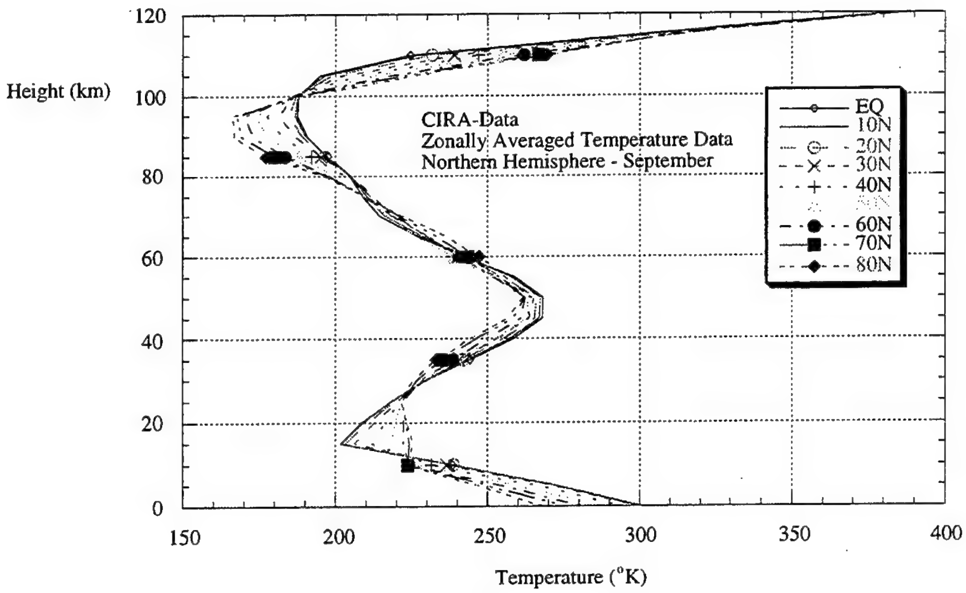

Figure 45a. Zonally averaged temperature data as a function of height during the month of September for the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

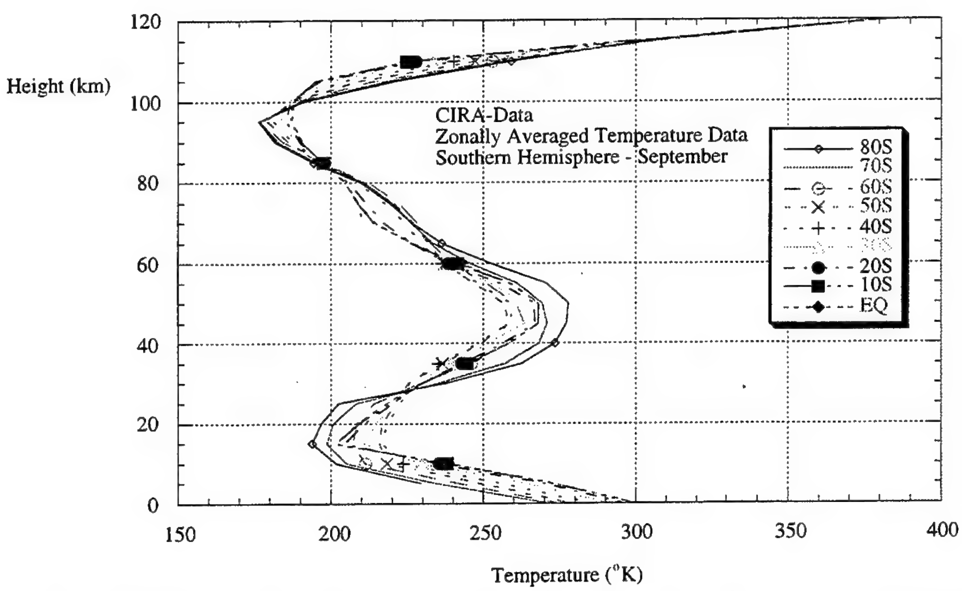

Figure 45b. Zonally averaged temperature data as a function of height during the month of September for the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

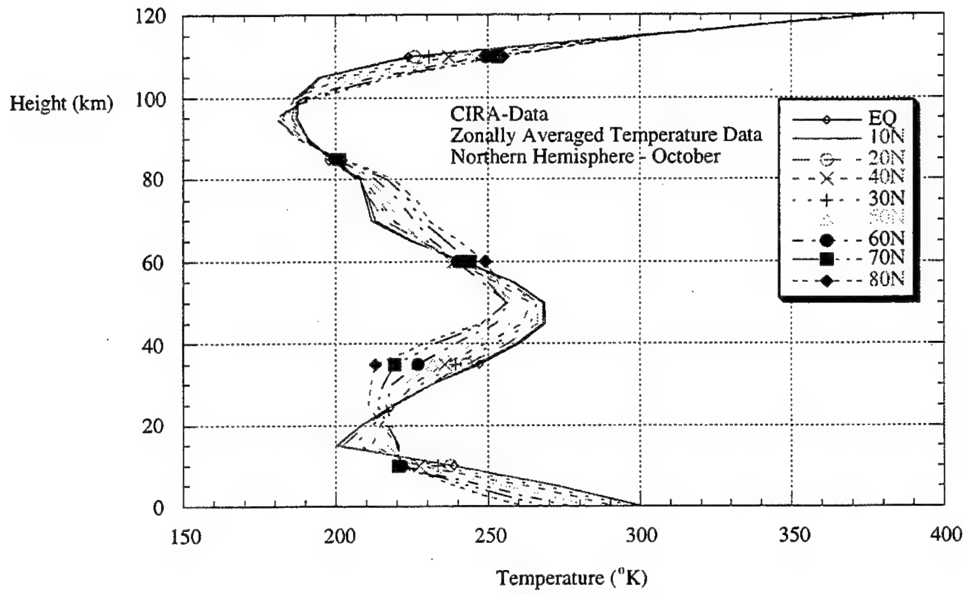

Figure 46a. Zonally averaged temperature data as a function of height during the month of October for the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

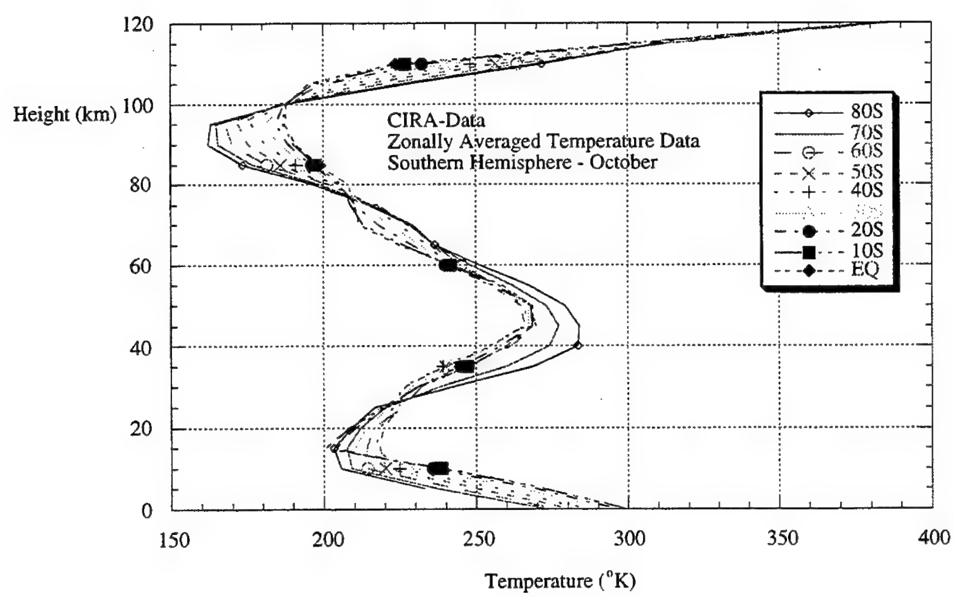

Figure 46b. Zonally averaged temperature data as a function of height during the month of October for the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

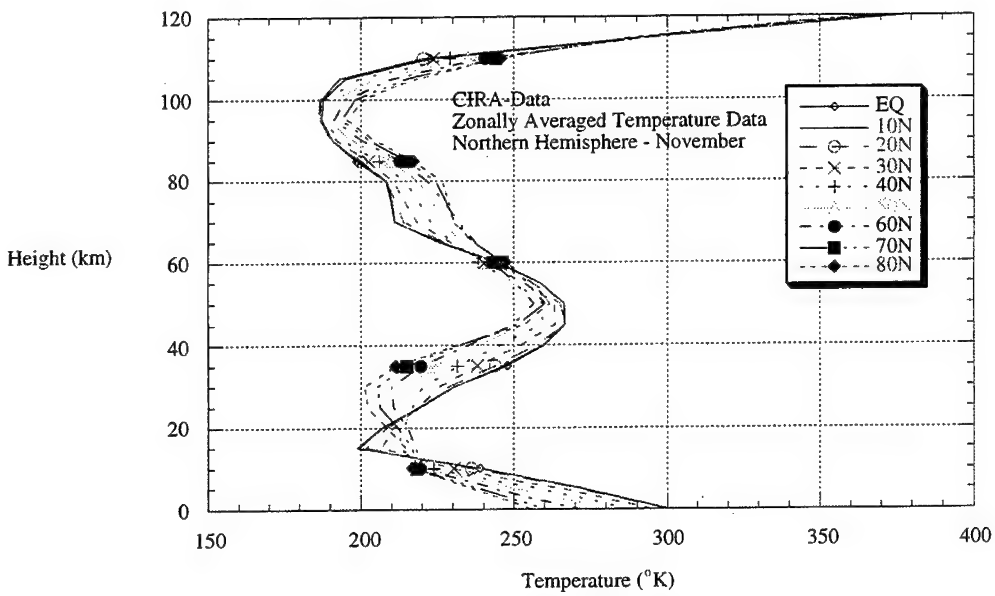

Figure 47a. Zonally averaged temperature data as a function of height during the month of November for the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

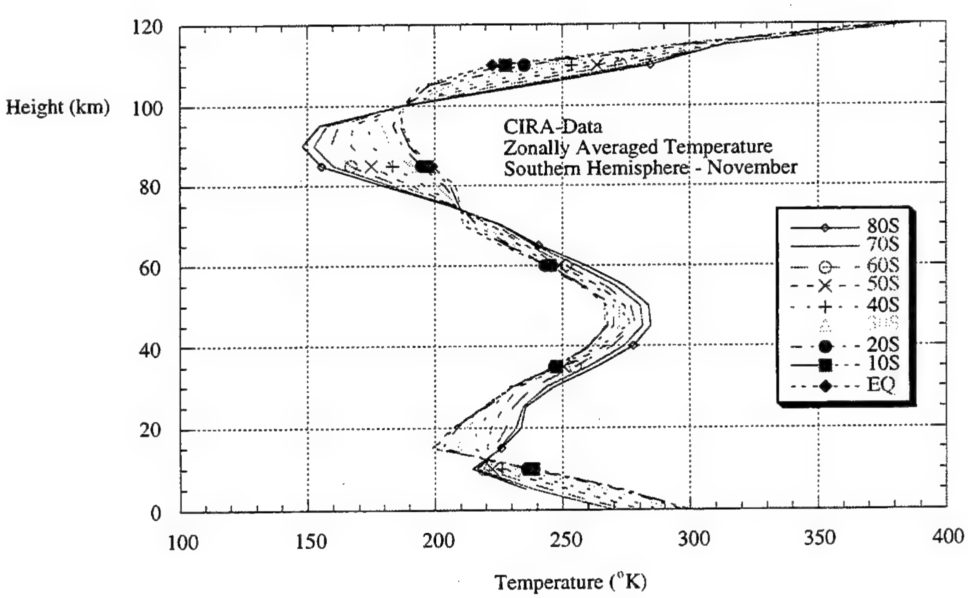

Figure 47b. Zonally averaged temperature data as a function of height during the month of November for the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

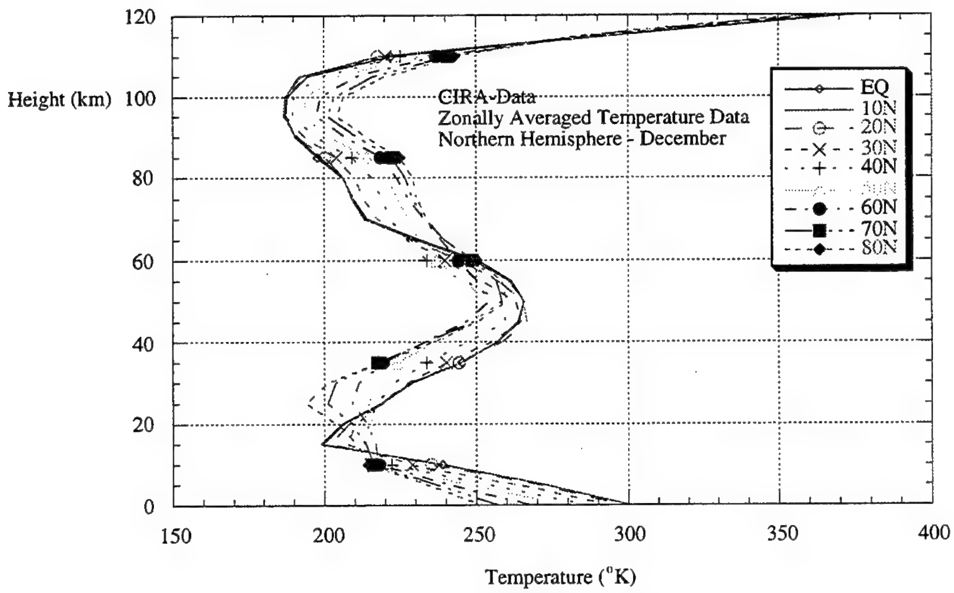

Figure 48a. Zonally averaged temperature data as a function of height during the month of December for the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

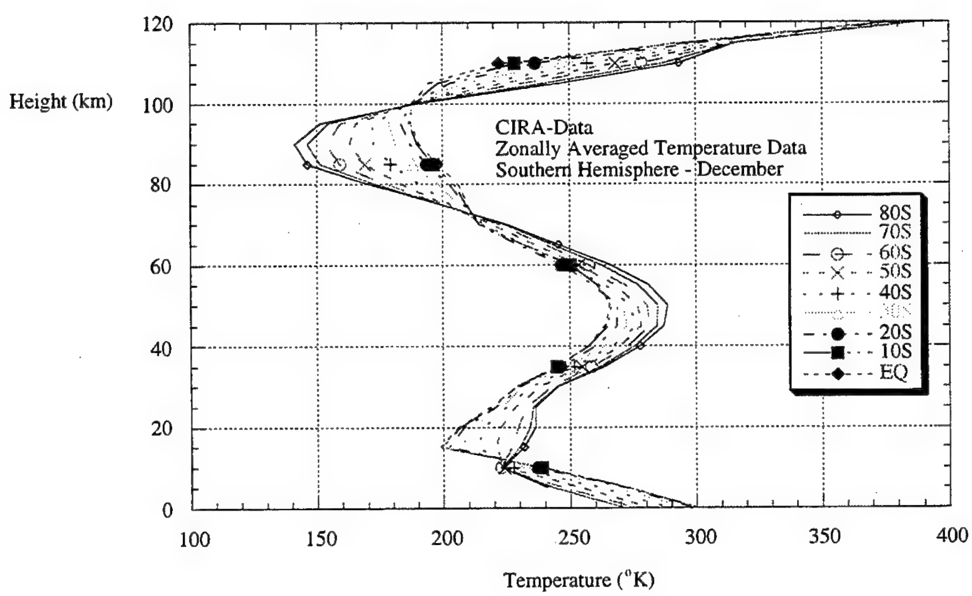

Figure 48b. Zonally averaged temperature data as a function of height during the month of December for the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

2.2 Zonally Averaged Wind Speed Profiles

The data are based on the COSPAR International Reference Atmosphere: 1986 (0 km to 120 km) Figures 49 through 60

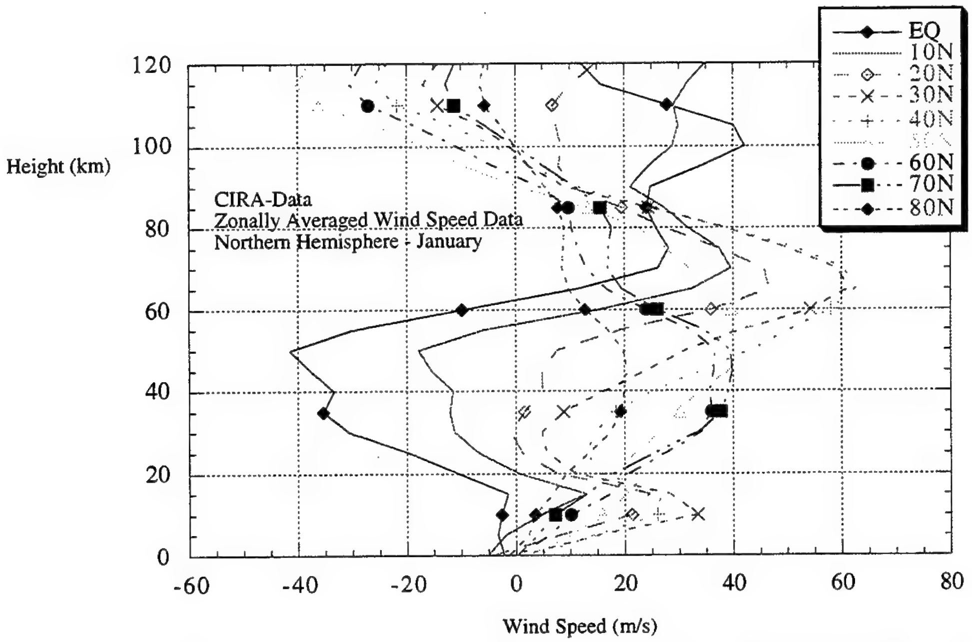

Figure 49a. Zonally averaged wind speed data as a function of height during the month of January for the northern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

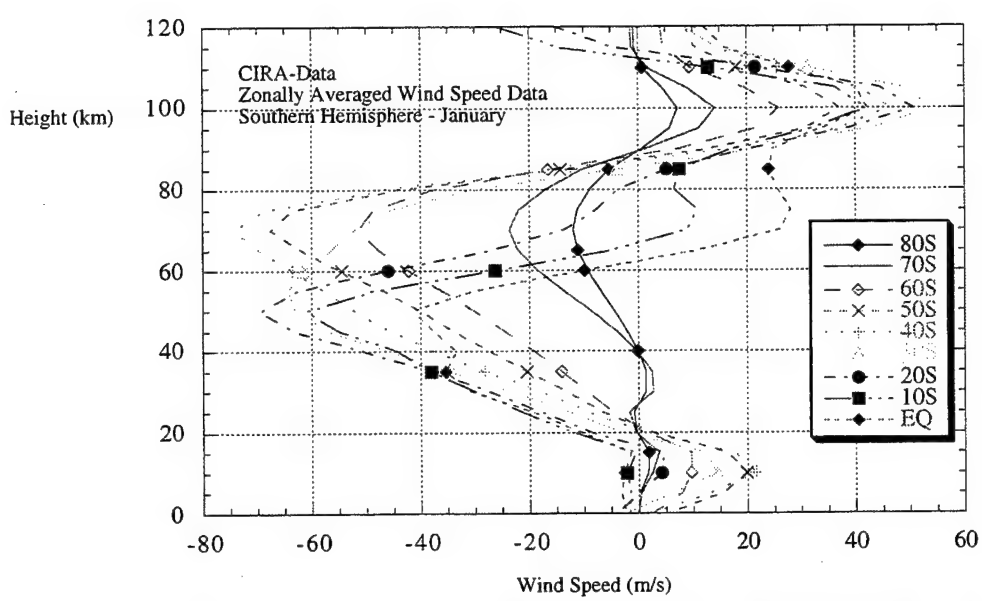

Figure 49b. Zonally averaged wind speed data as a function of height during the month of January for the southern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

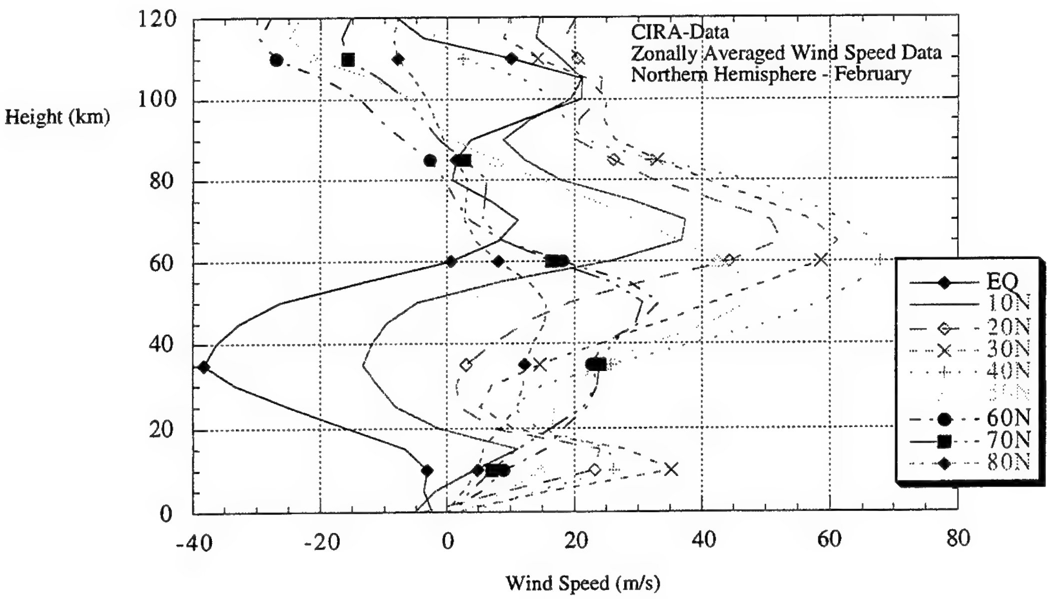

Figure 50a. Zonally averaged wind speed data as a function of height during the month of February for the northern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

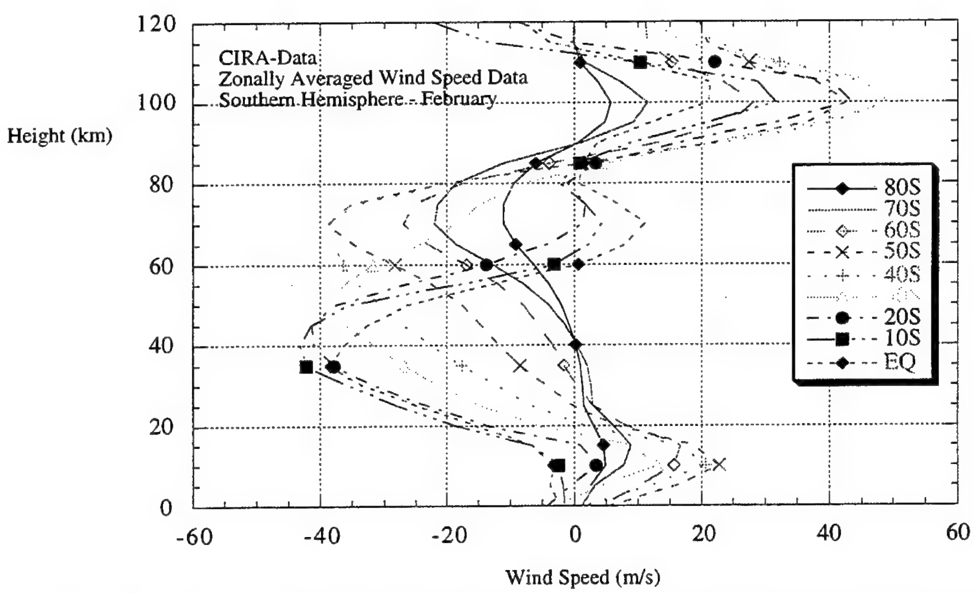

Figure 50b. Zonally averaged wind speed data as a function of height during the month of February for the southern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

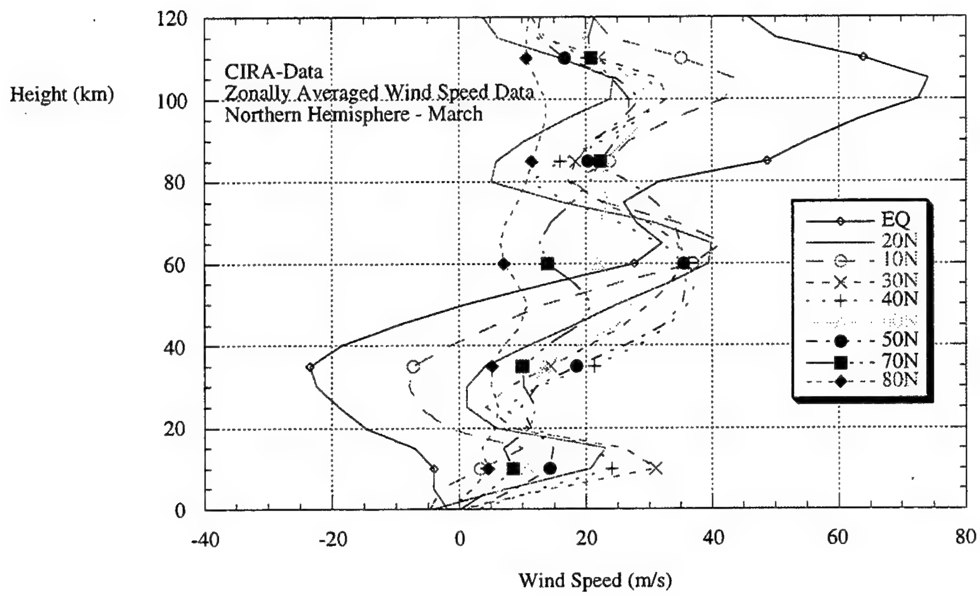

Figure 51a. Zonally averaged wind speed data as a function of height during the month of March for the northern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

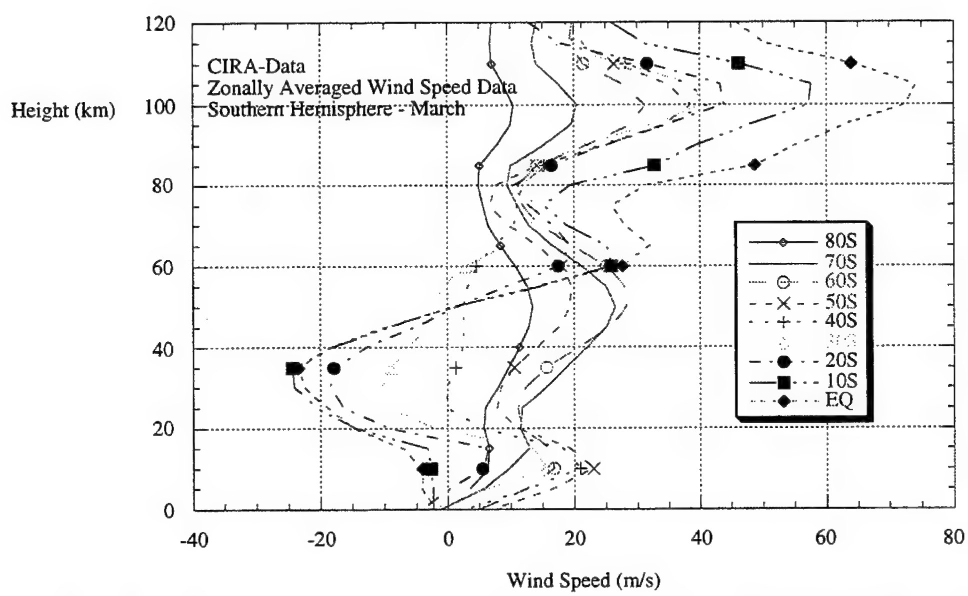

Figure 51b. Zonally averaged wind speed data as a function of height during the month of March for the southern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

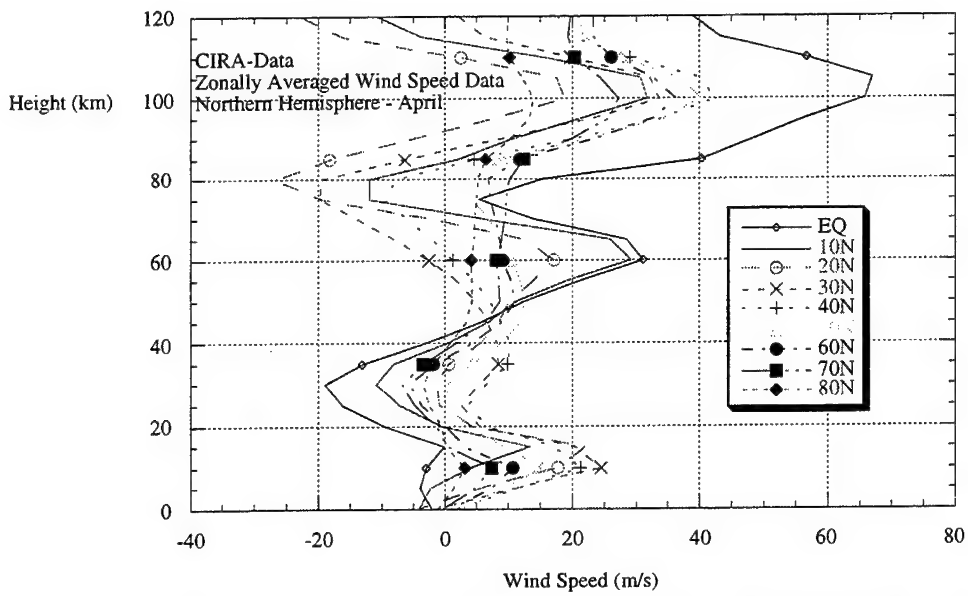

Figure 52a. Zonally averaged wind speed data as a function of height during the month of April for the northern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

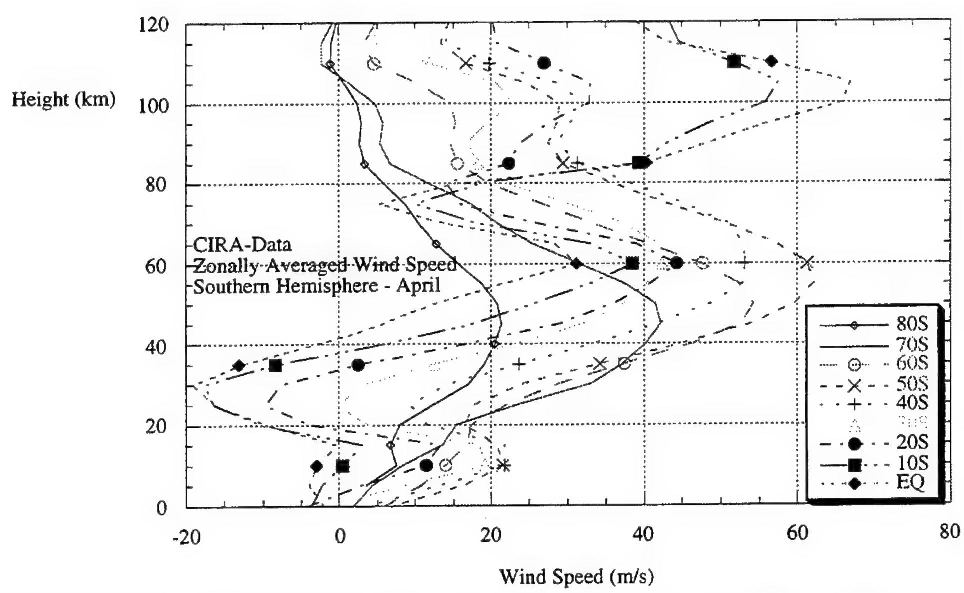

Figure 52b. Zonally averaged wind speed data as a function of height during the month of April for the southern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

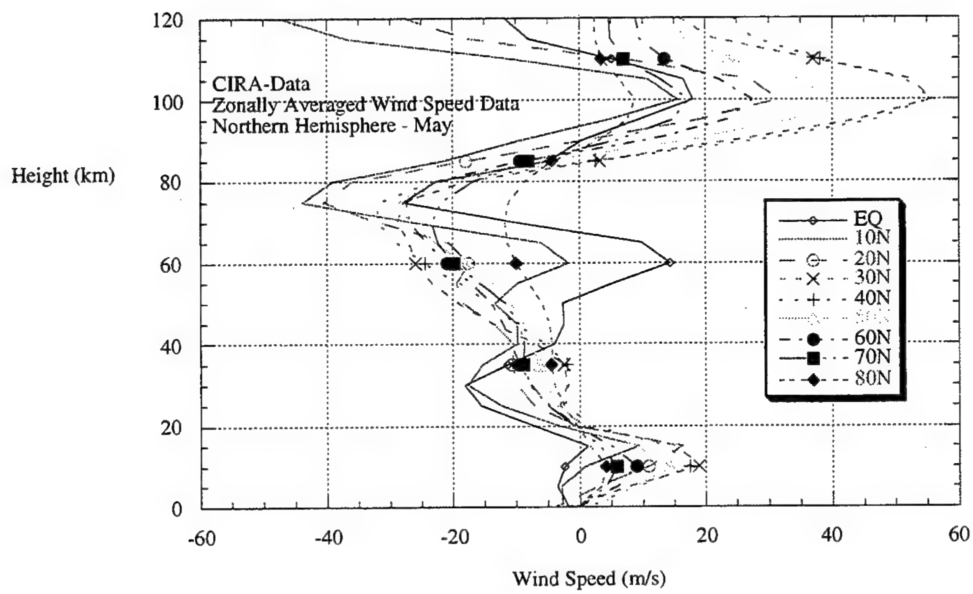

Figure 53a. Zonally averaged wind speed data as a function of height during the month of May for the northern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

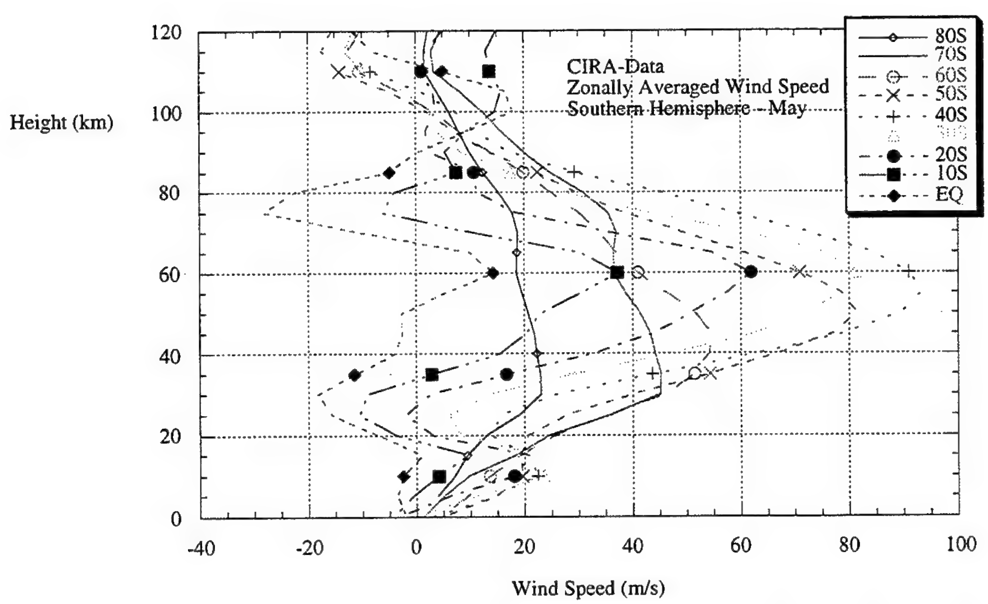

Figure 53b. Zonally averaged wind speed data as a function of height during the month of May for the southern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

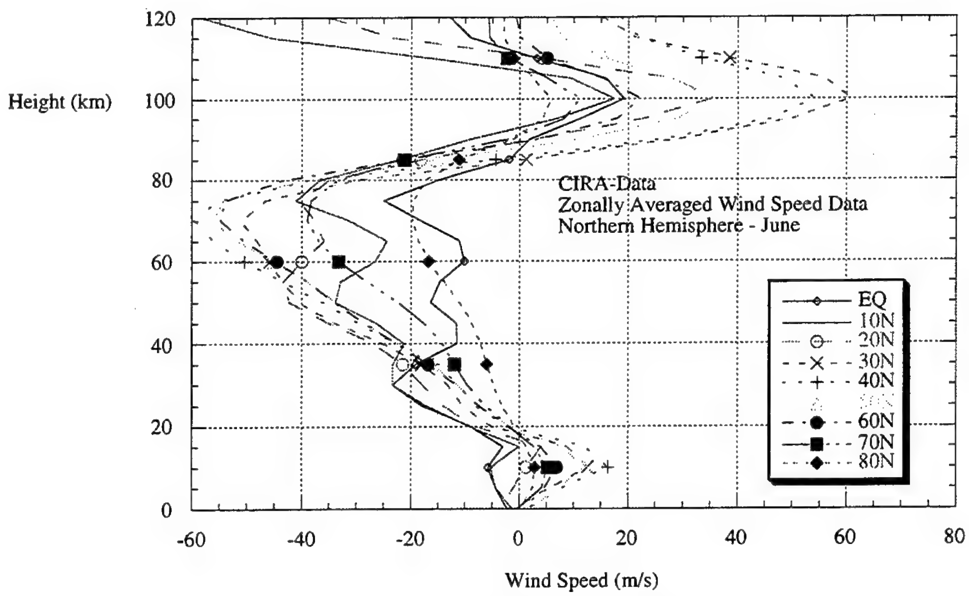

Figure 54a. Zonally averaged wind speed data as a function of height during the month of June for the northern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

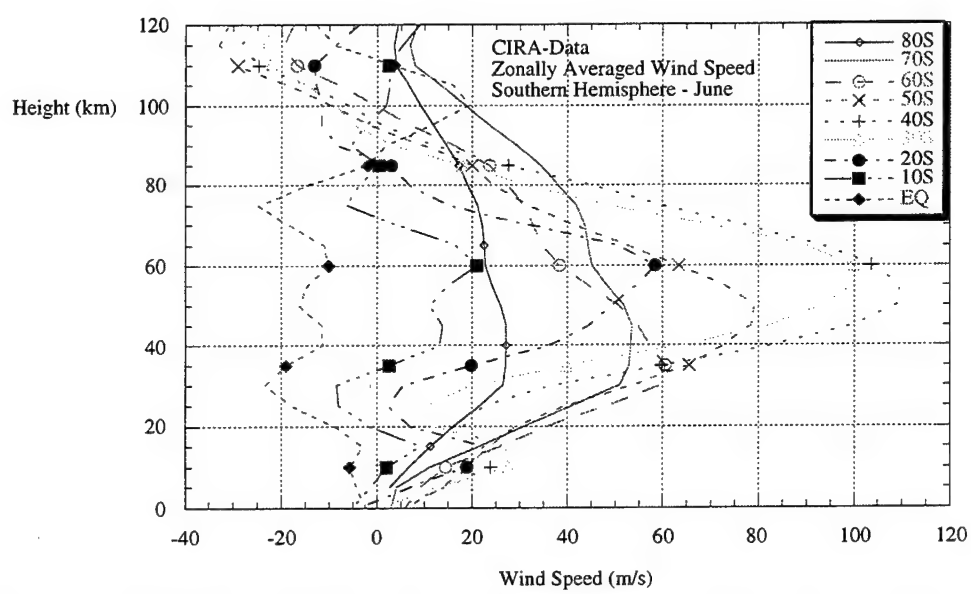

Figure 54b. Zonally averaged wind speed data as a function of height during the month of June for the southern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

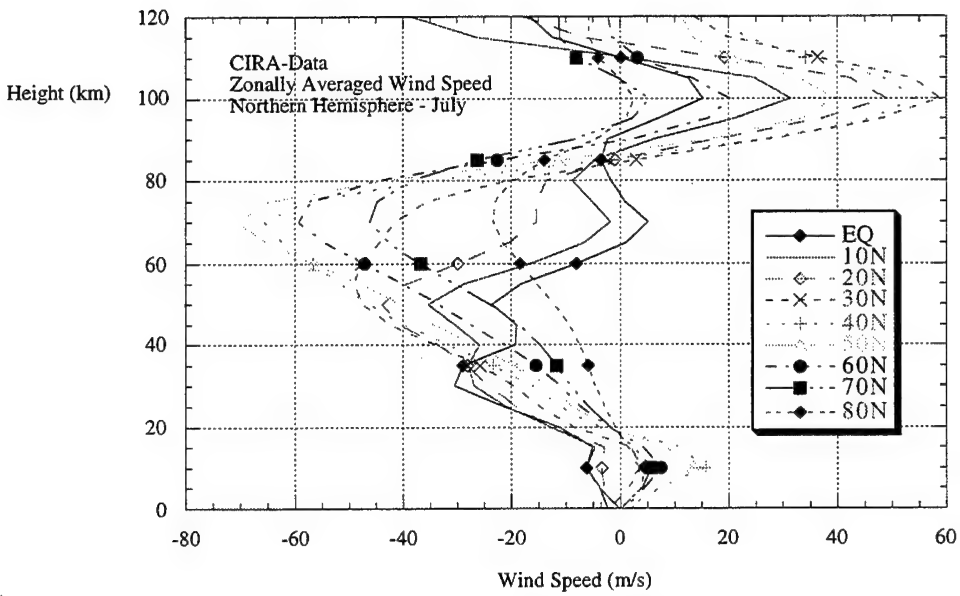

Figure 55a. Zonally averaged wind speed data as a function of height during the month of July for the northern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

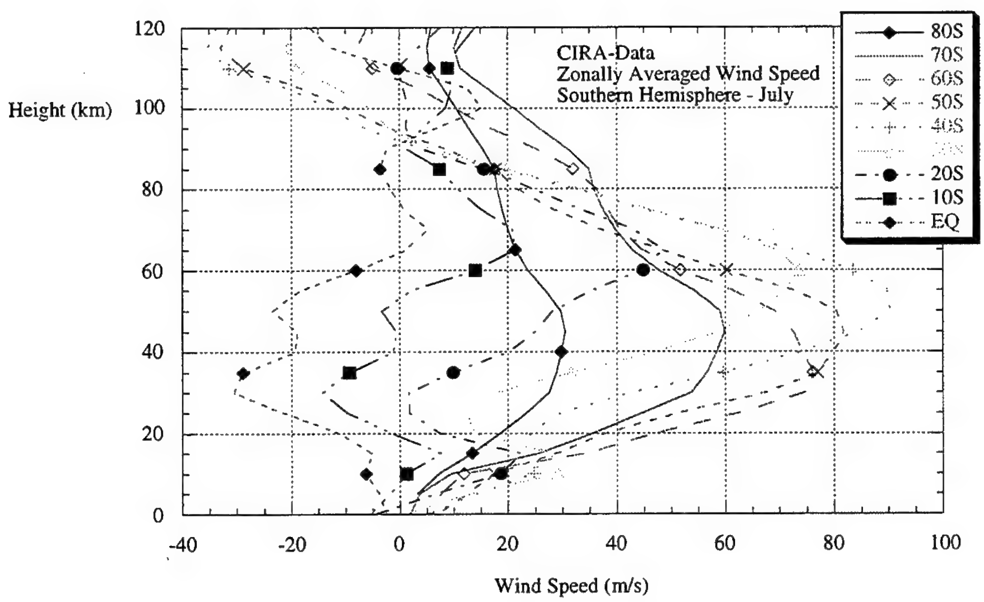

Figure 55b. Zonally averaged wind speed data as a function of height during the month of July for the southern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

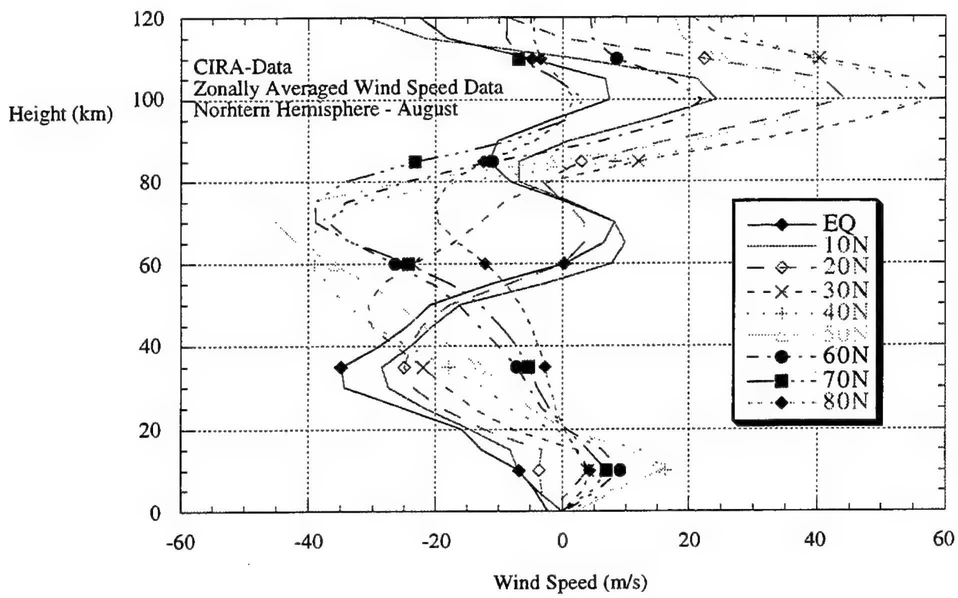

Figure 56a. Zonally averaged wind speed data as a function of height during the month of August for the northern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

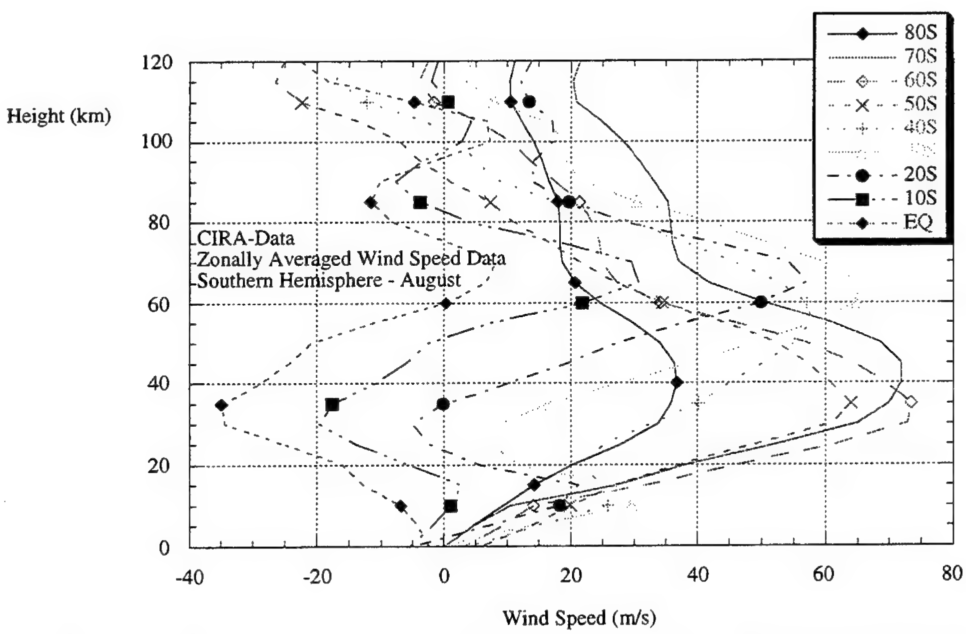

Figure 56b. Zonally averaged wind speed data as a function of height during the month of August for the southern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

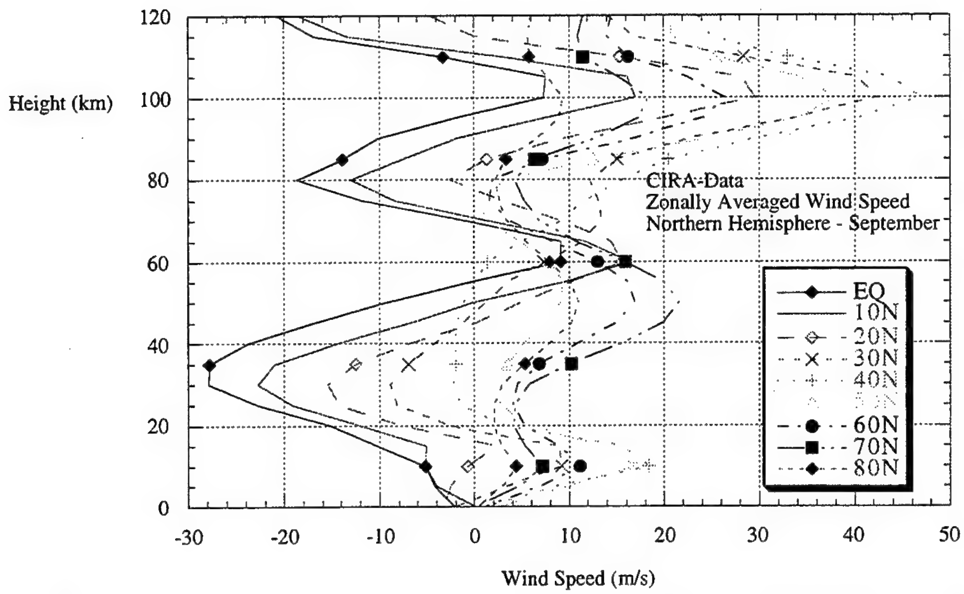

Figure 57a. Zonally averaged wind speed data as a function of height during the month of September for the northern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

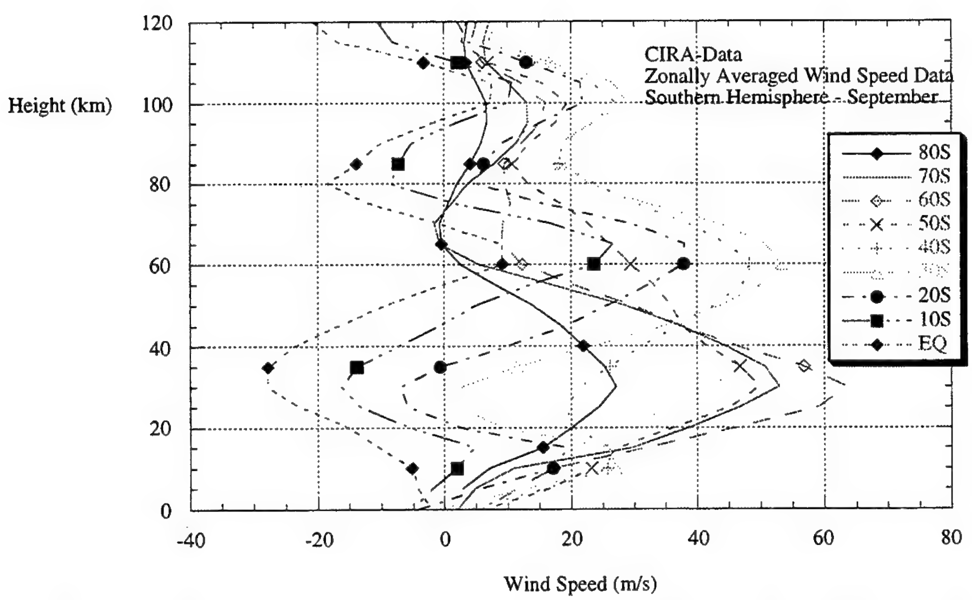

Figure 57b. Zonally averaged wind speed data as a function of height during the month of September for the southern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

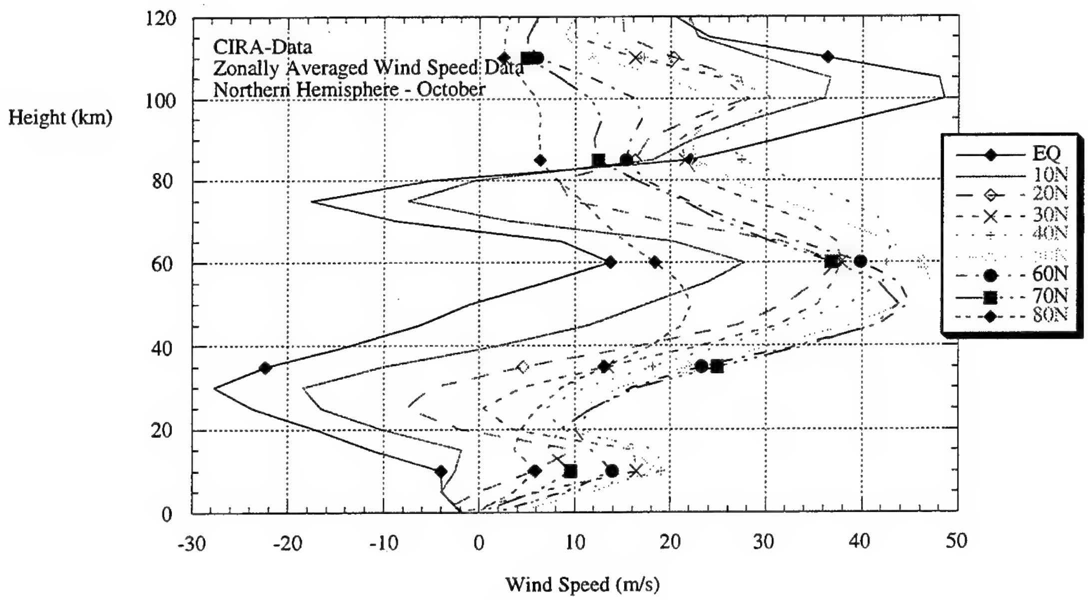

Figure 58a. Zonally averaged wind speed data as a function of height during the month of October for the northern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

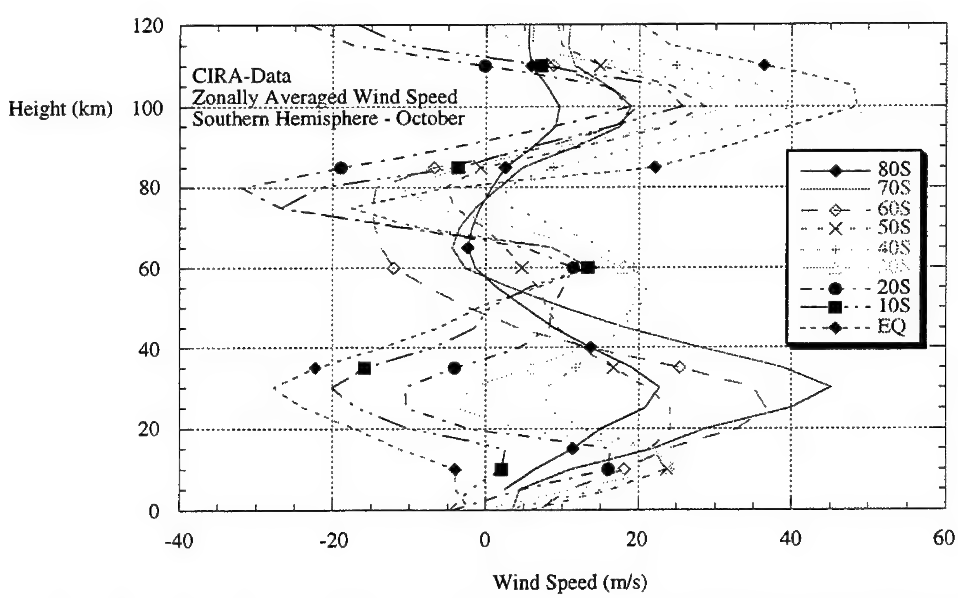

Figure 58b. Zonally averaged wind speed data as a function of height during the month of October for the southern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

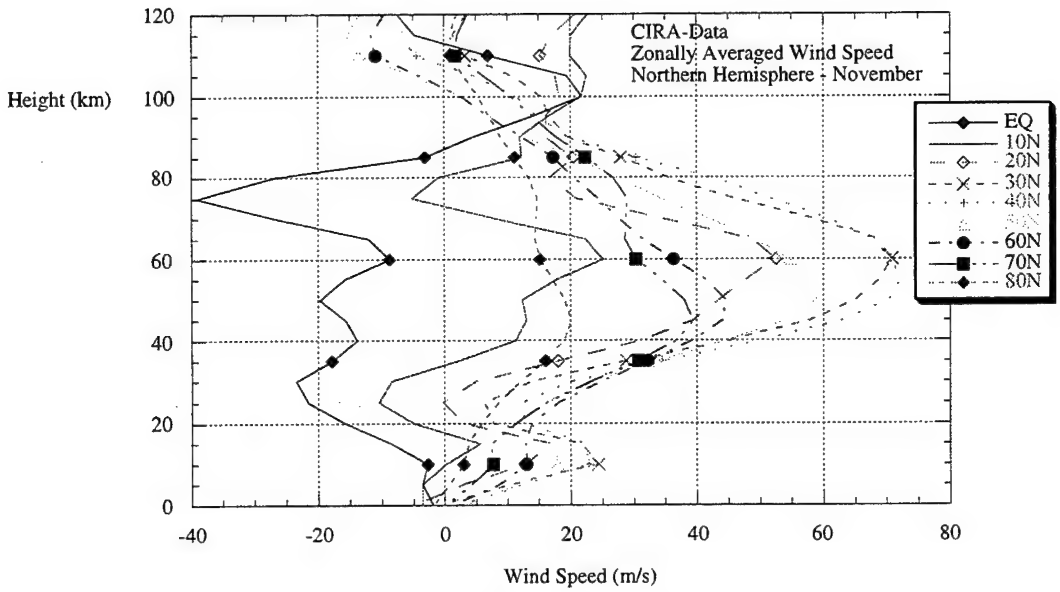

Figure 59a. Zonally averaged wind speed data as a function of height during the month of November for the northern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

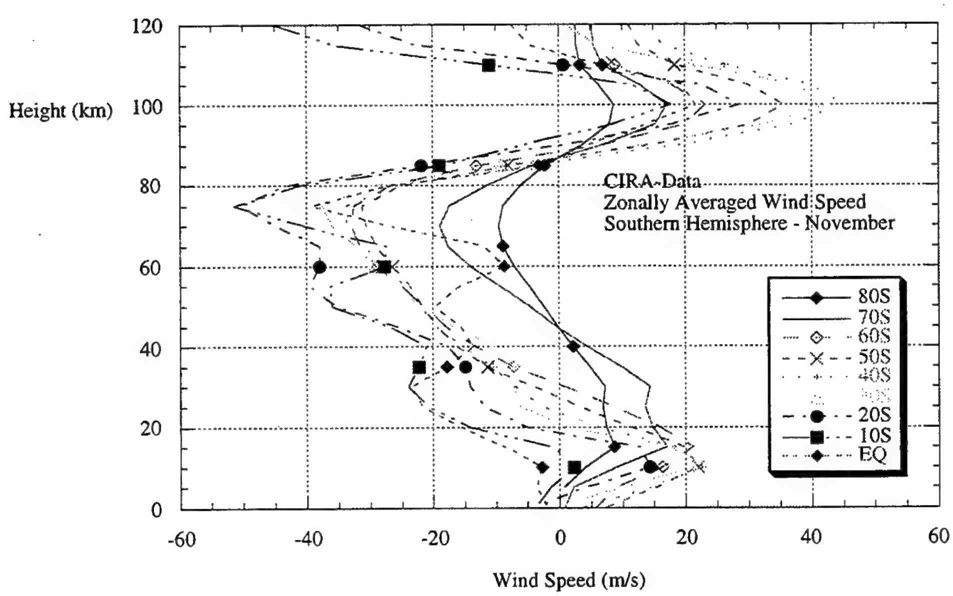

Figure 59b. Zonally averaged wind speed data as a function of height during the month of November for the southern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

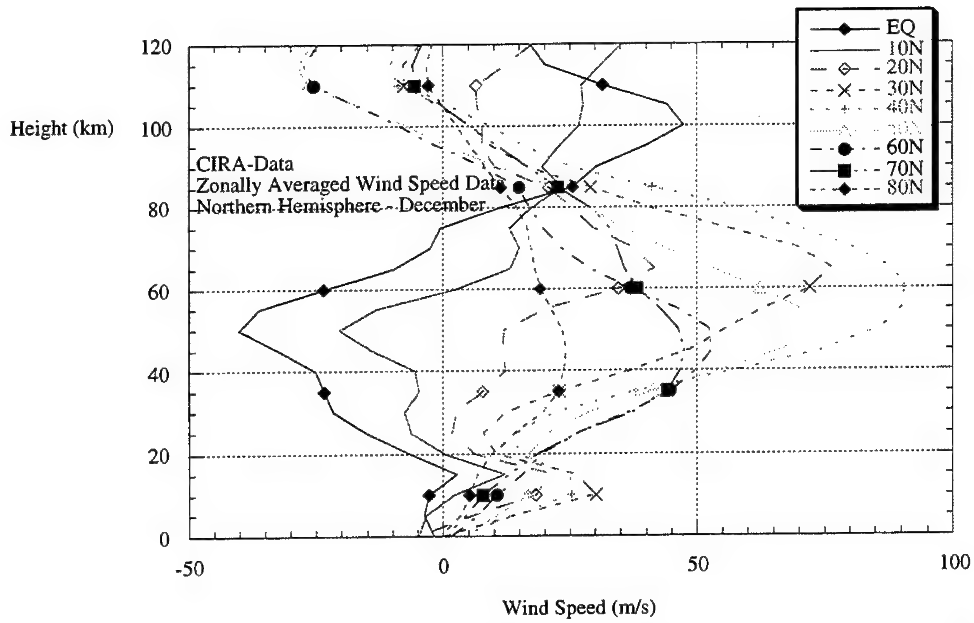

Figure 60a. Zonally averaged wind speed data as a function of height during the month of December for the northern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

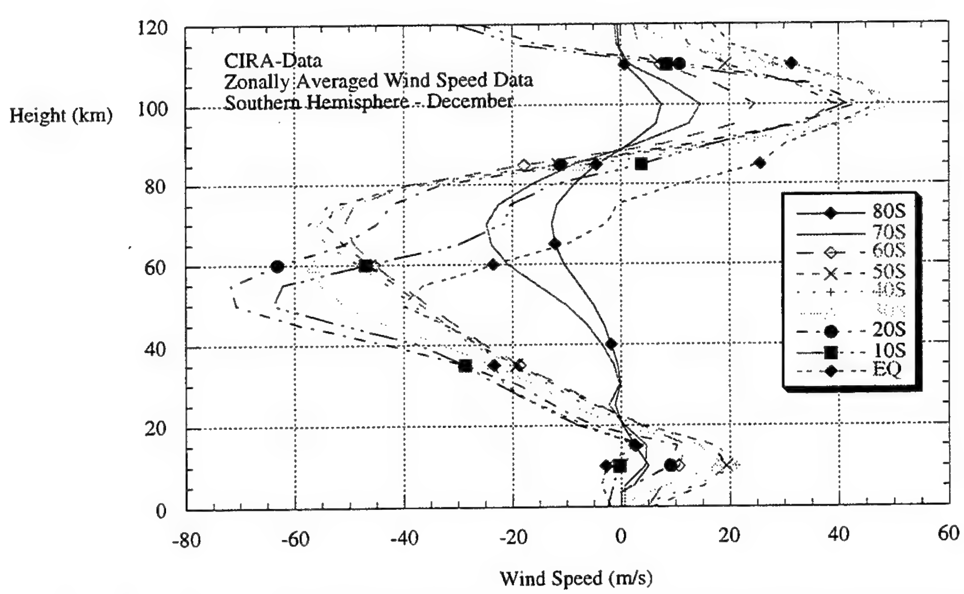

Figure 60b. Zonally averaged wind speed data as a function of height during the month of December for the southern hemisphere. Positive values correspond to propagation from west-to-east, and negative values to propagation from east-to-west. [Figure constructed based on the *CIRA* (1986) data set.]

2.3 Zonally Averaged Sound Speed Profiles

The data are based on the COSPAR International Reference Atmosphere: 1986 (0 km to 120 km) Figures 61 through 72.

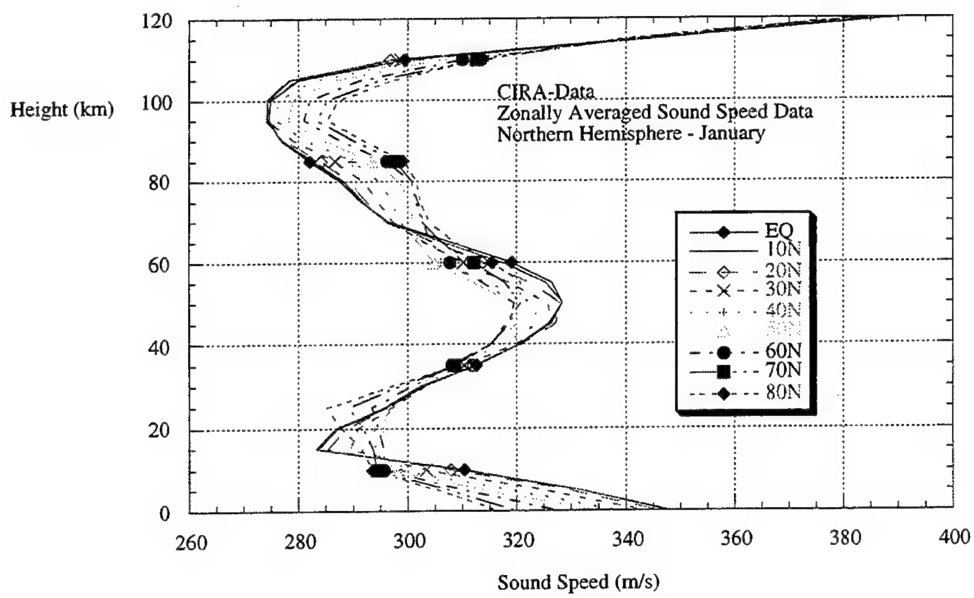

Figure 61a. Zonally averaged sound speed data as a function of height during the month of January in the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

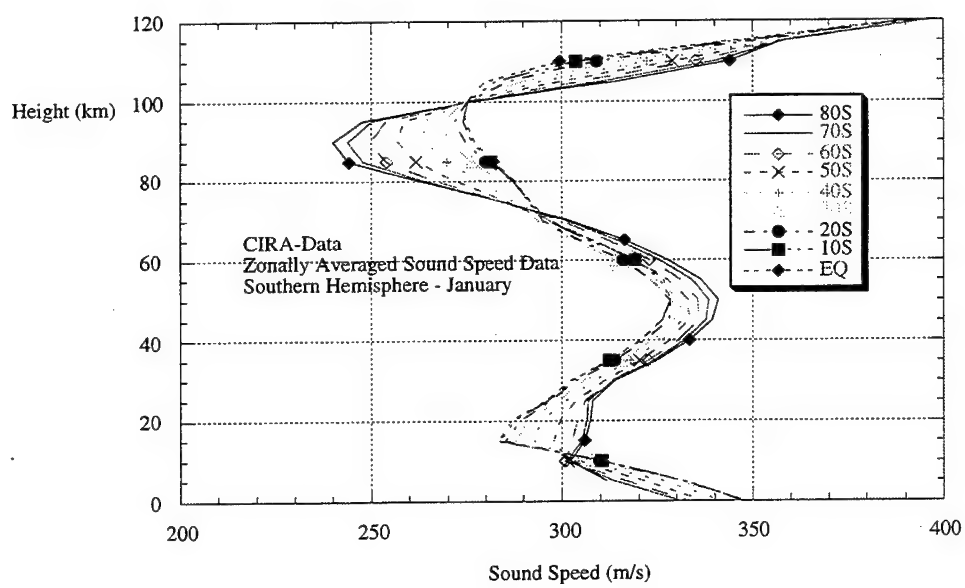

Figure 61b. Zonally averaged sound speed data as a function of height during the month of January in the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

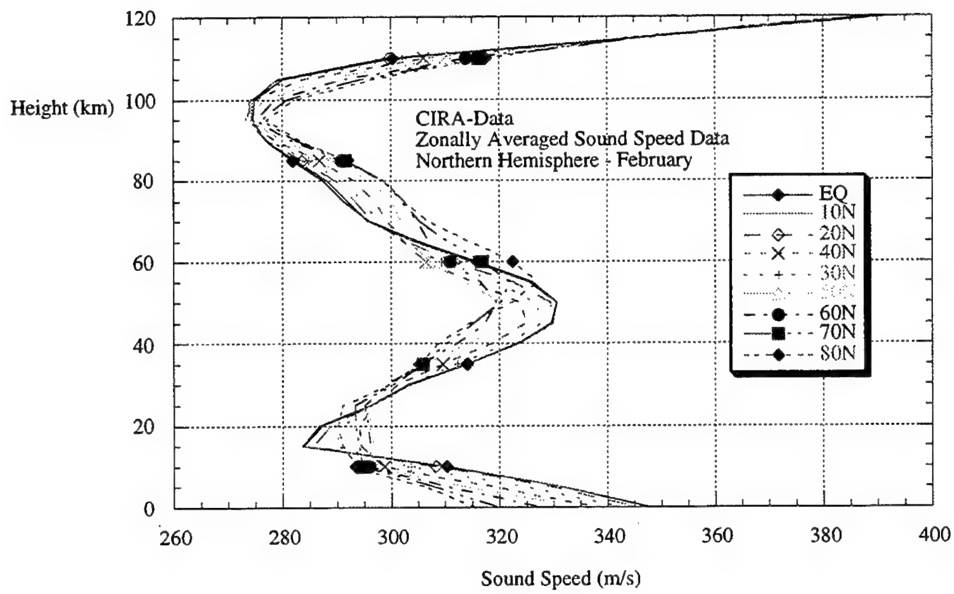

Figure 62a. Zonally averaged sound speed data as a function of height during the month of February in the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

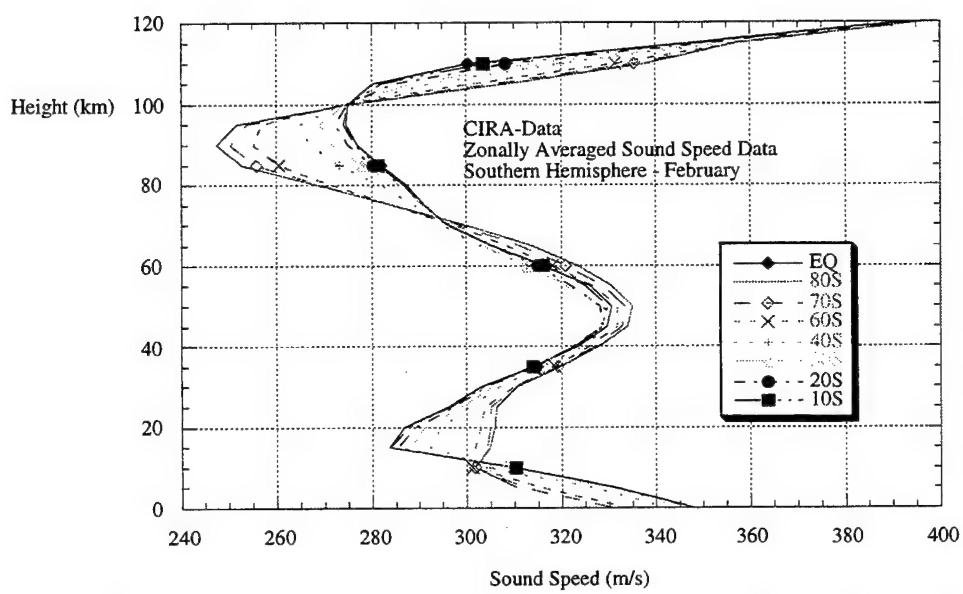

Figure 62b. Zonally averaged sound speed data as a function of height during the month of February in the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

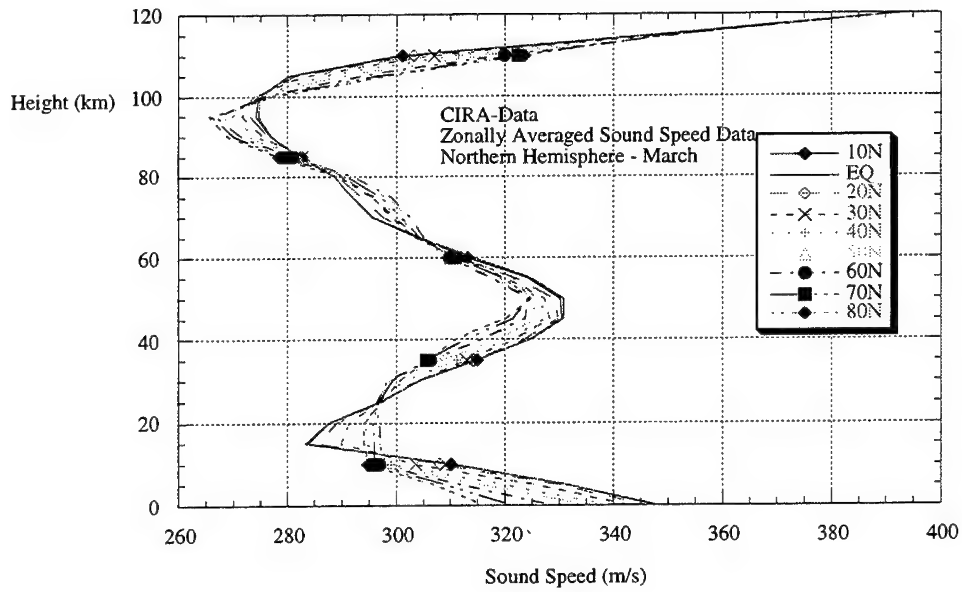

Figure 63a. Zonally averaged sound speed data as a function of height during the month of March in the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

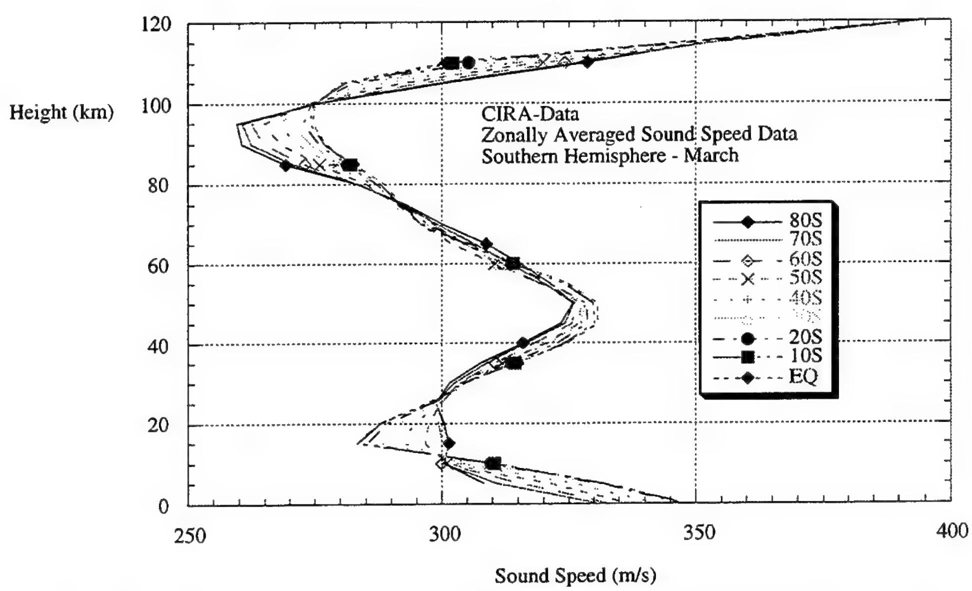

Figure 63b. Zonally averaged sound speed data as a function of height during the month of March in the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

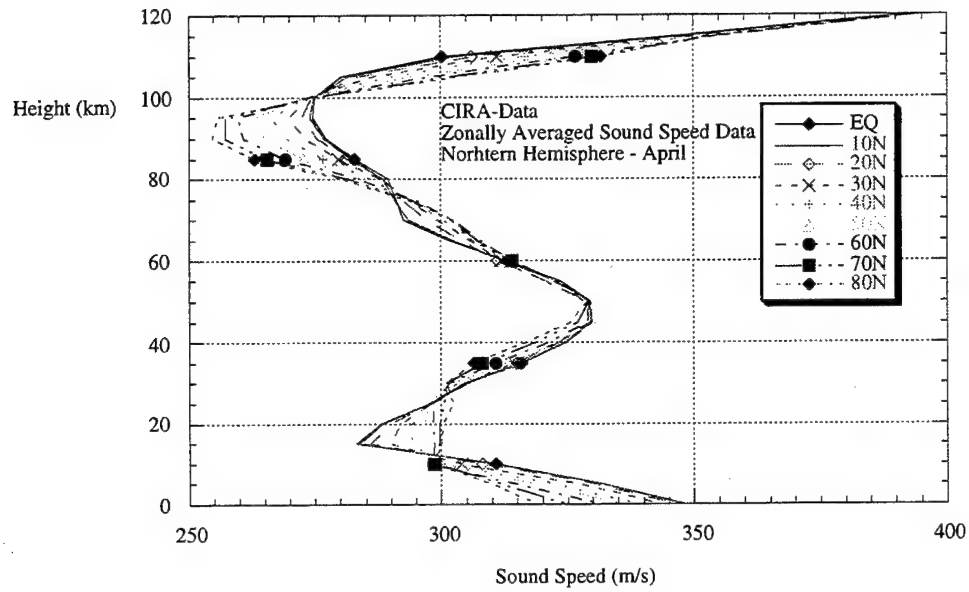

Figure 64a. Zonally averaged sound speed data as a function of height during the month of April in the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

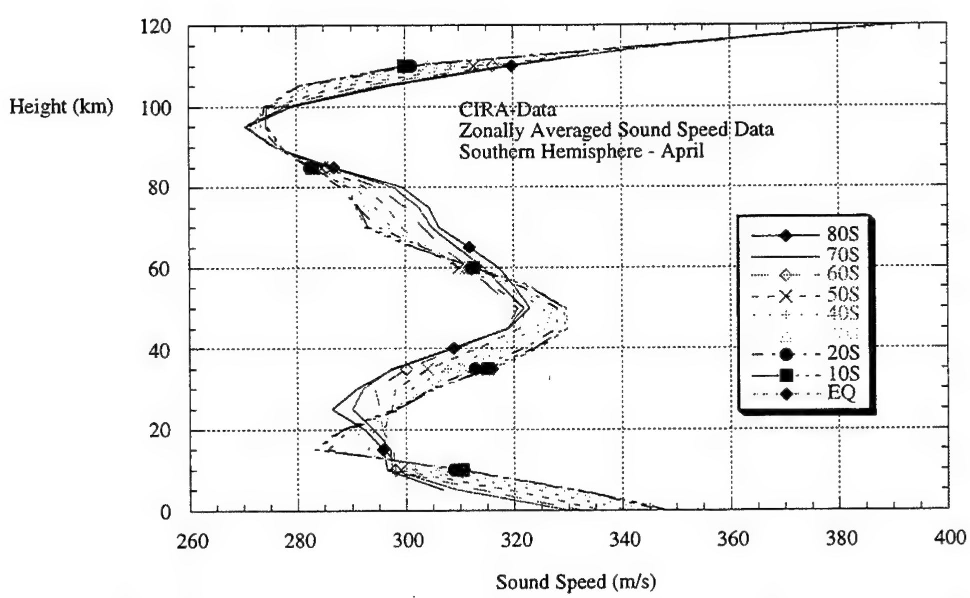

Figure 64b. Zonally averaged sound speed data as a function of height during the month of April in the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

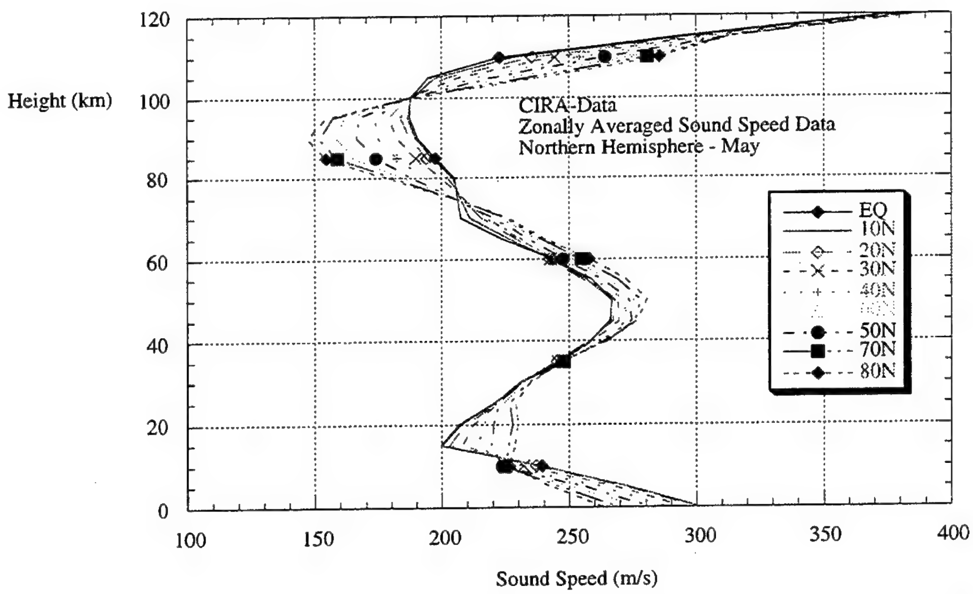

Figure 65a. Zonally averaged sound speed data as a function of height during the month of May in the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

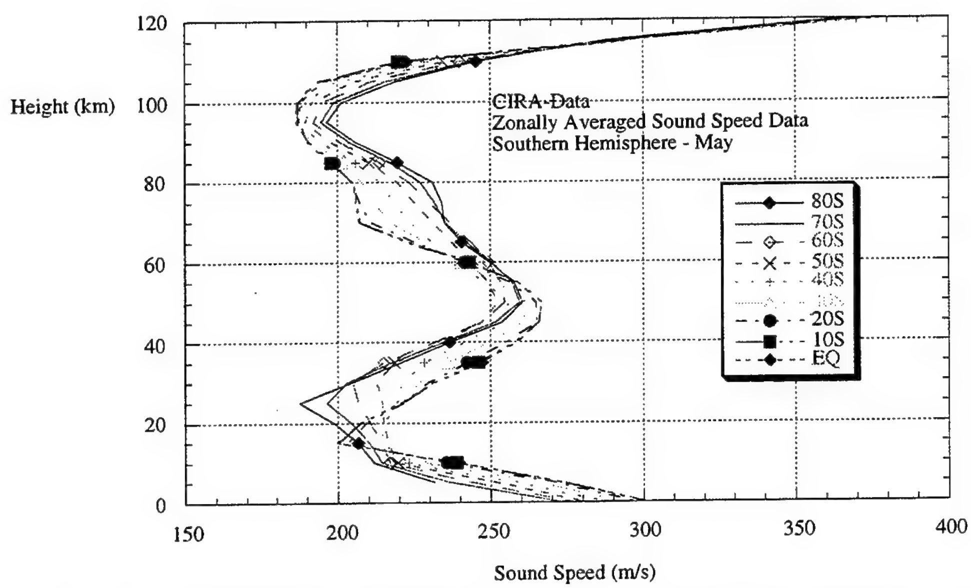

Figure 65b. Zonally averaged sound speed data as a function of height during the month of May in the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

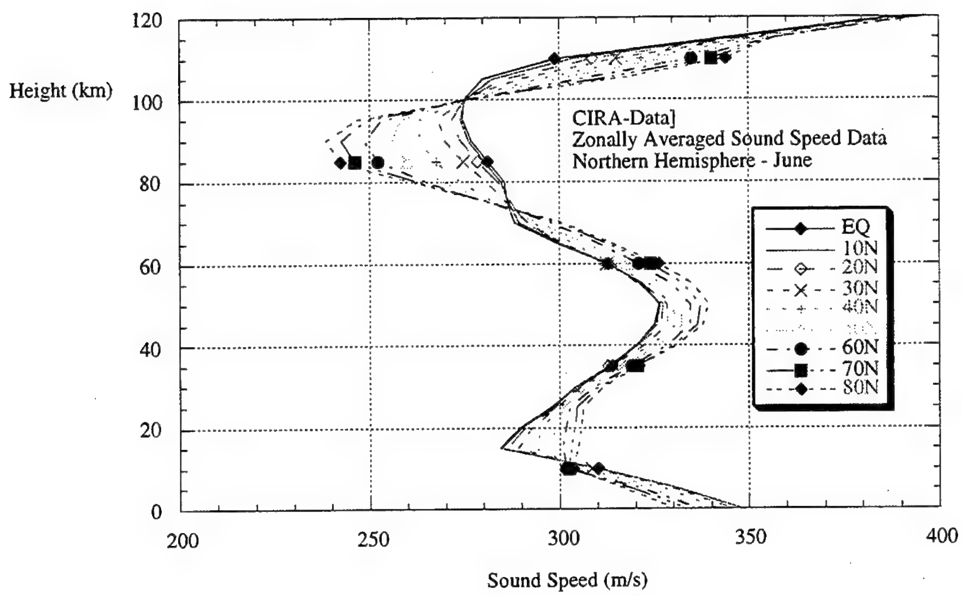

Figure 66a. Zonally averaged sound speed data as a function of height during the month of June in the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

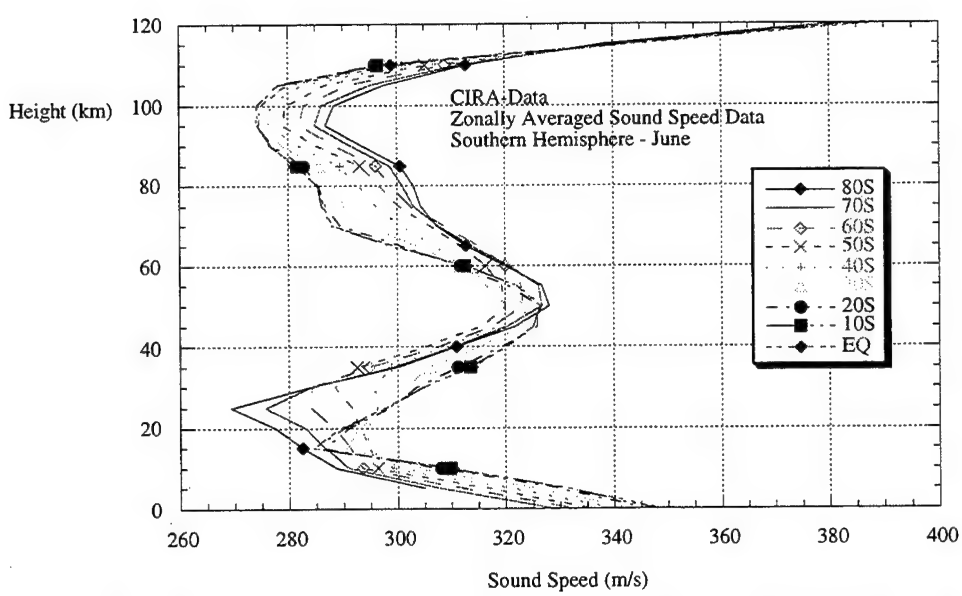

Figure 66b. Zonally averaged sound speed data as a function of height during the month of June in the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

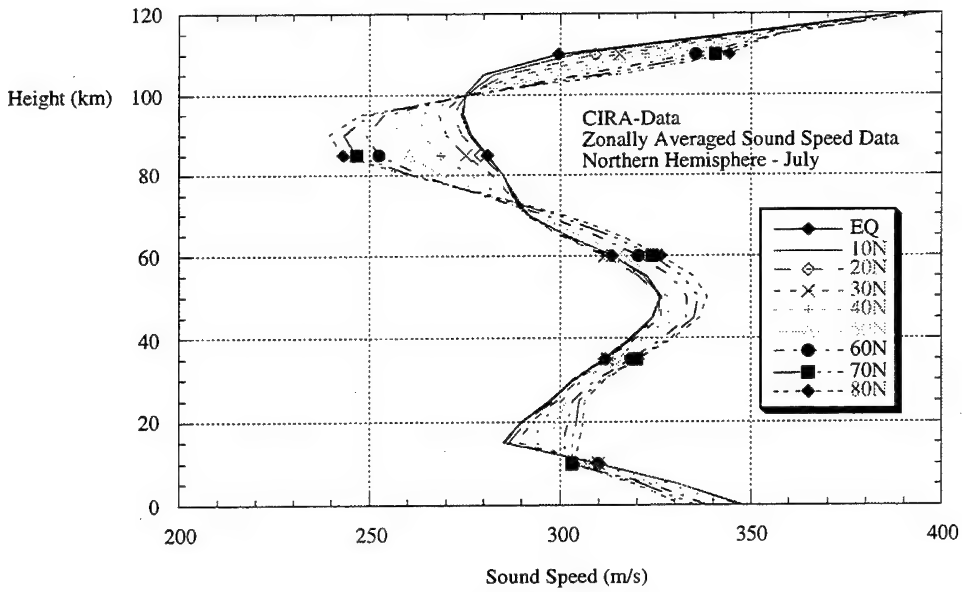

Figure 67a. Zonally averaged sound speed data as a function of height during the month of July in the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

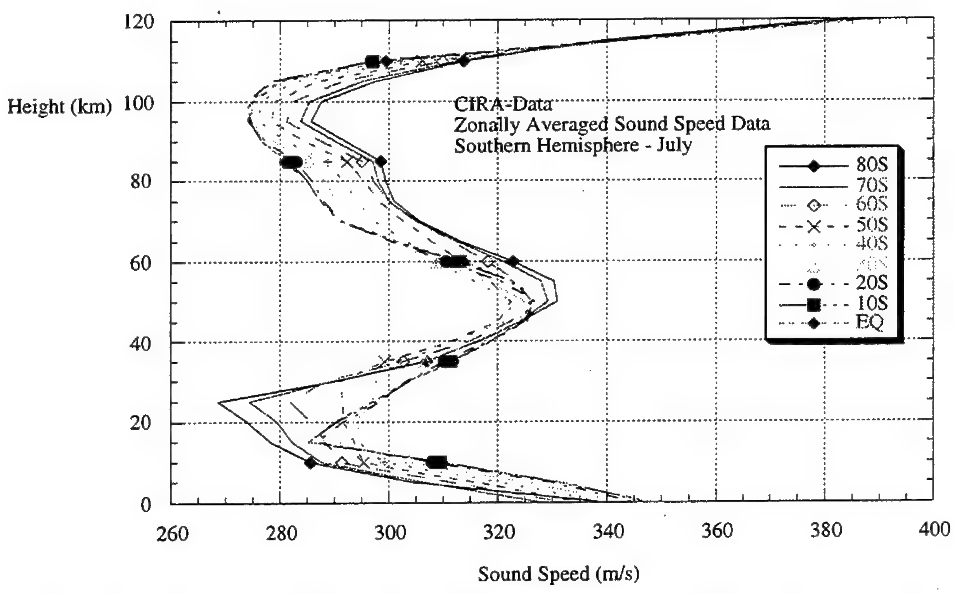

Figure 67b. Zonally averaged sound speed data as a function of height during the month of July in the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

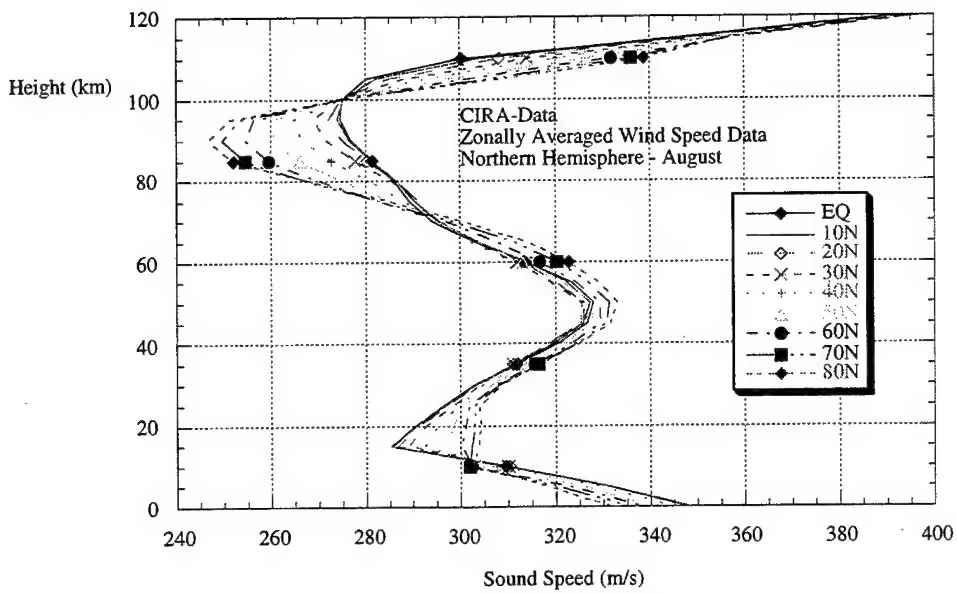

Figure 68a. Zonally averaged sound speed data as a function of height during the month of August in the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

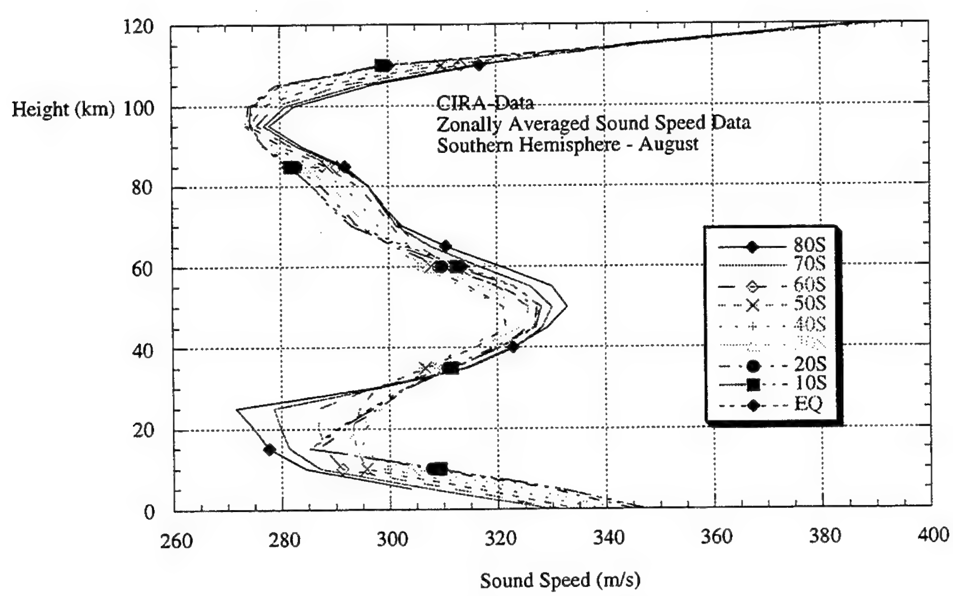

Figure 68b. Zonally averaged sound speed data as a function of height during the month of August in the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

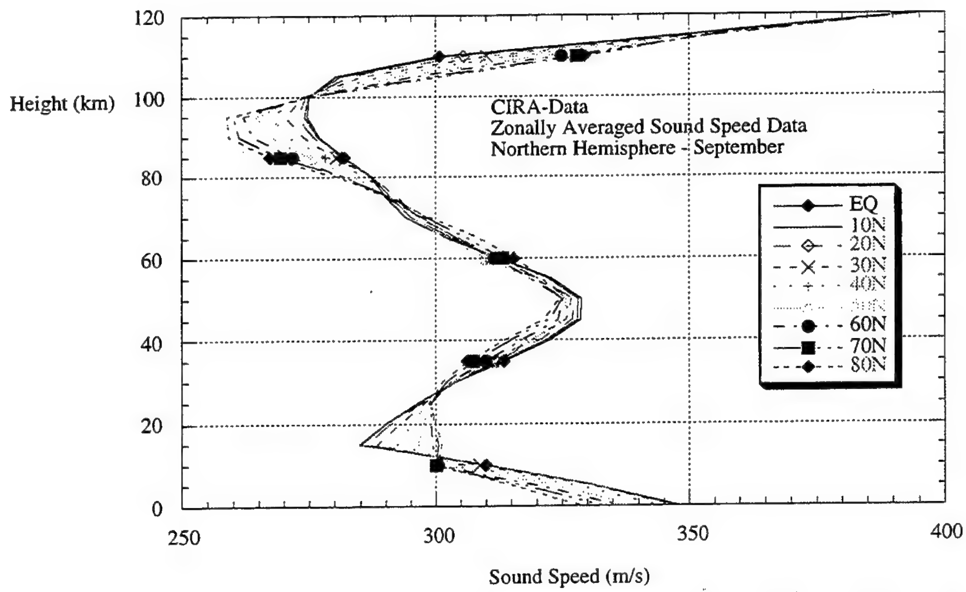

Figure 69a. Zonally averaged sound speed data as a function of height during the month of September in the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

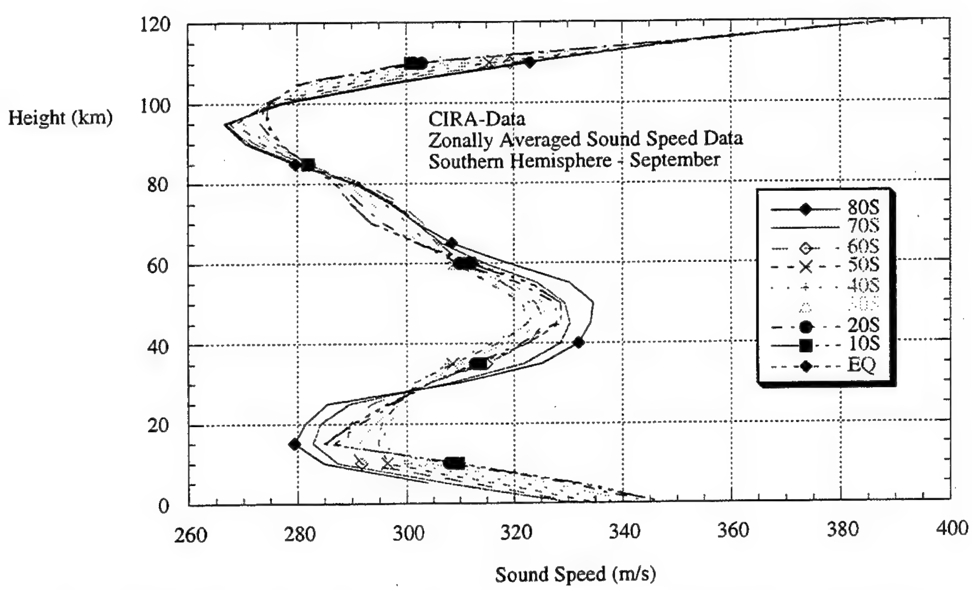

Figure 69b. Zonally averaged sound speed data as a function of height during the month of September in the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

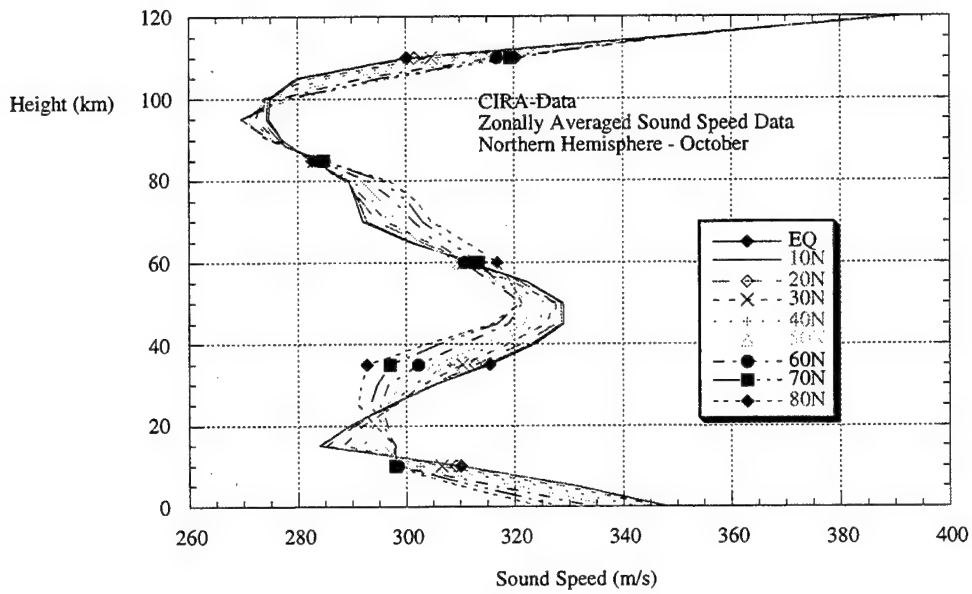

Figure 70a. Zonally averaged sound speed data as a function of height during the month of October in the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

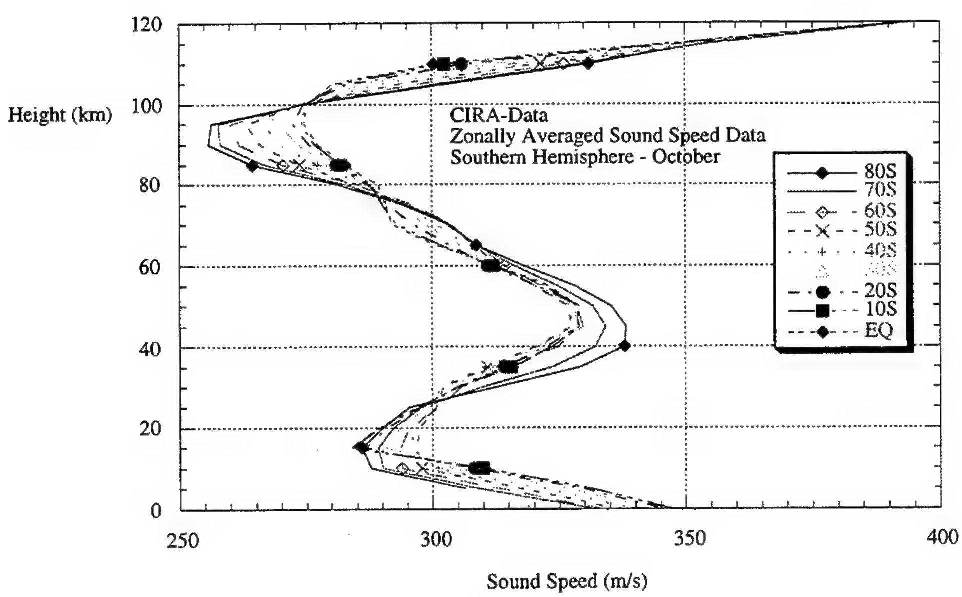

Figure 70b. Zonally averaged sound speed data as a function of height during the month of October in the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

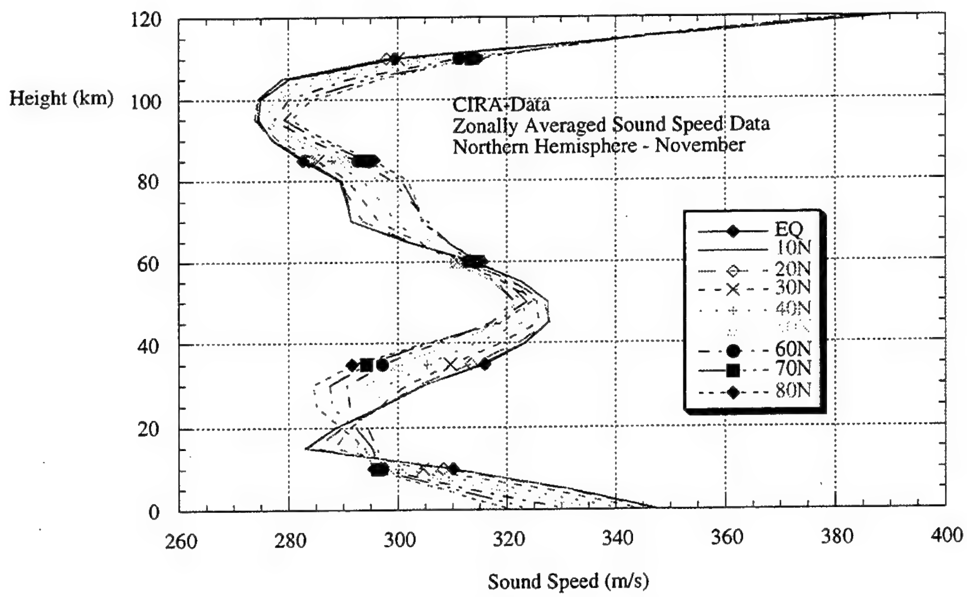

Figure 71a. Zonally averaged sound speed data as a function of height during the month of November in the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

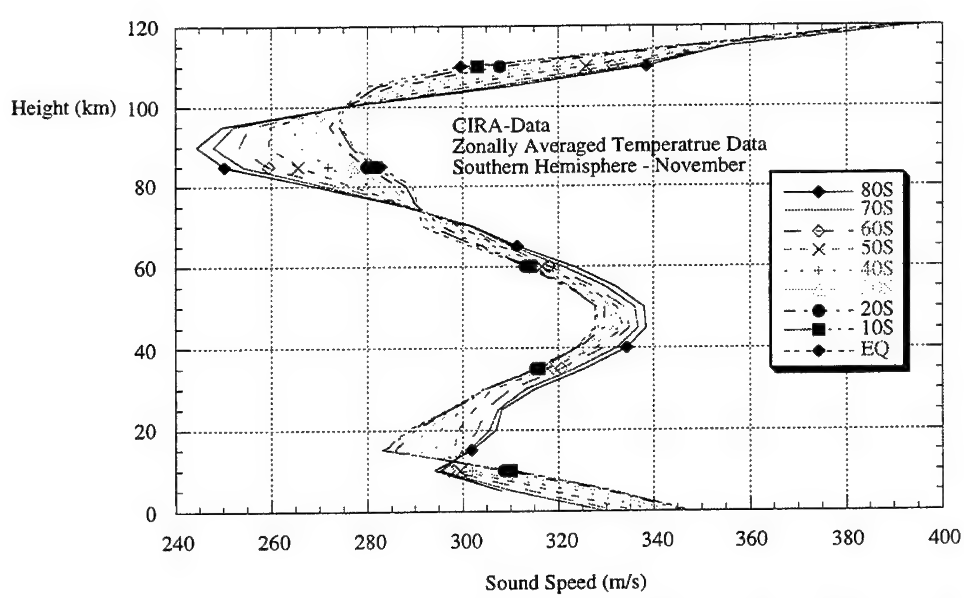

Figure 71b. Zonally averaged sound speed data as a function of height during the month of November in the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

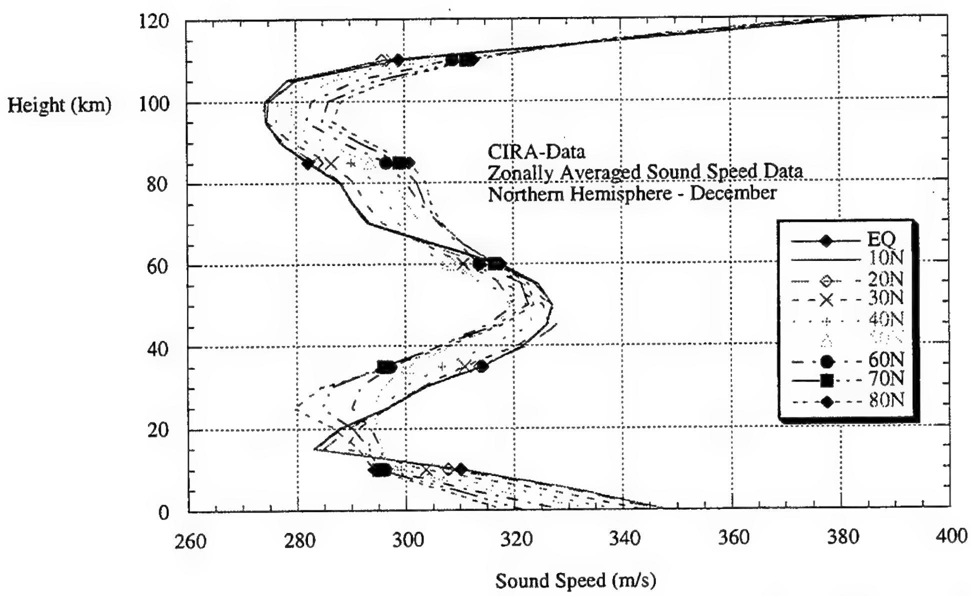

Figure 72a. Zonally averaged sound speed data as a function of height during the month of December in the northern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

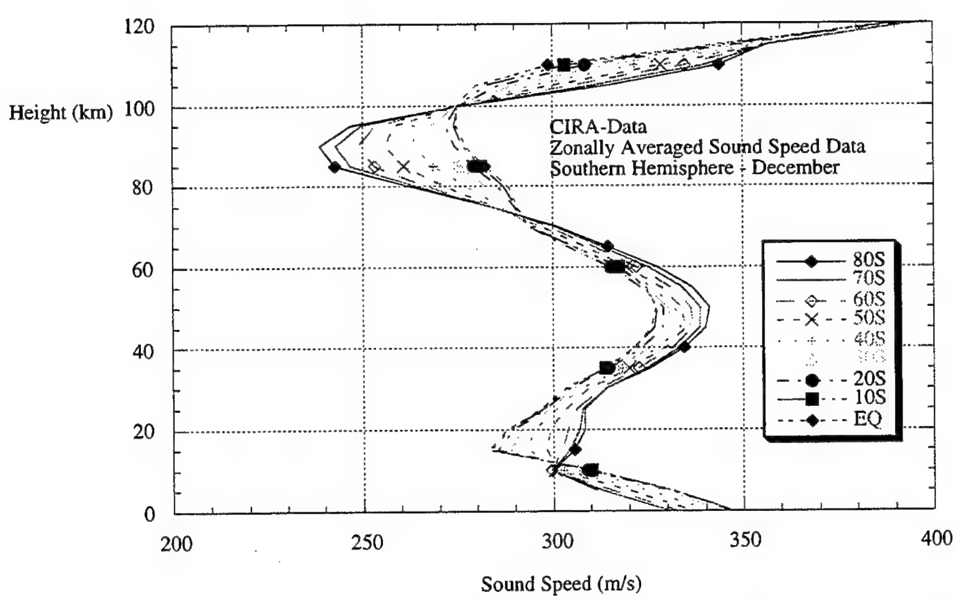

Figure 72b. Zonally averaged sound speed data as a function of height during the month of December in the southern hemisphere. [Figure constructed based on the *CIRA* (1986) data set.]

2.4 Zonally Averaged Effective Sound Speed Profiles

The data are based on the COSPAR International Reference Atmosphere: 1986 (0 km to 120 km) Figures 73 through 76.

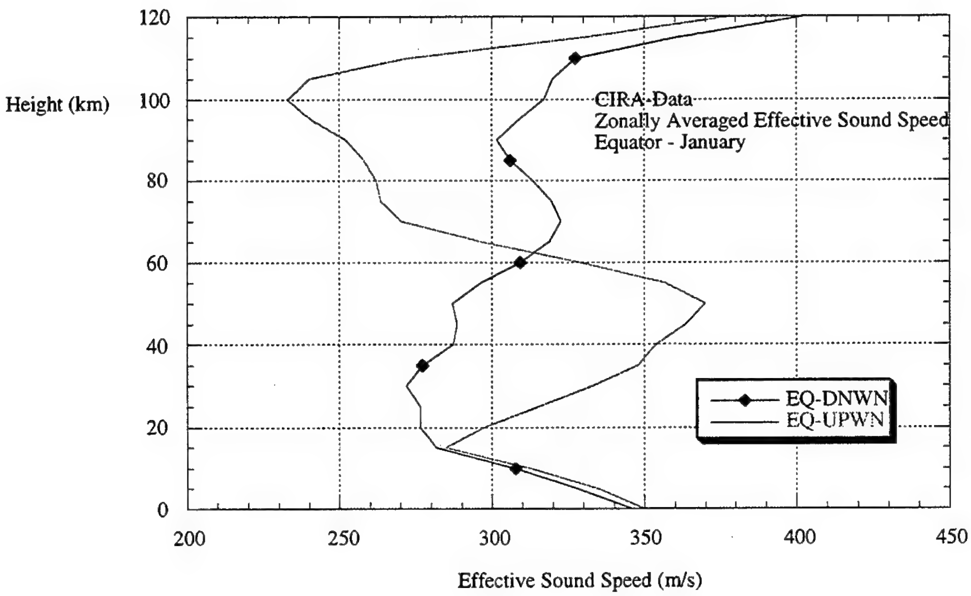

Figure 73a. Zonally averaged effective sound speed as a function of height during January at the equator. [Figure constructed based on the *CIRA* (1986) data set.]

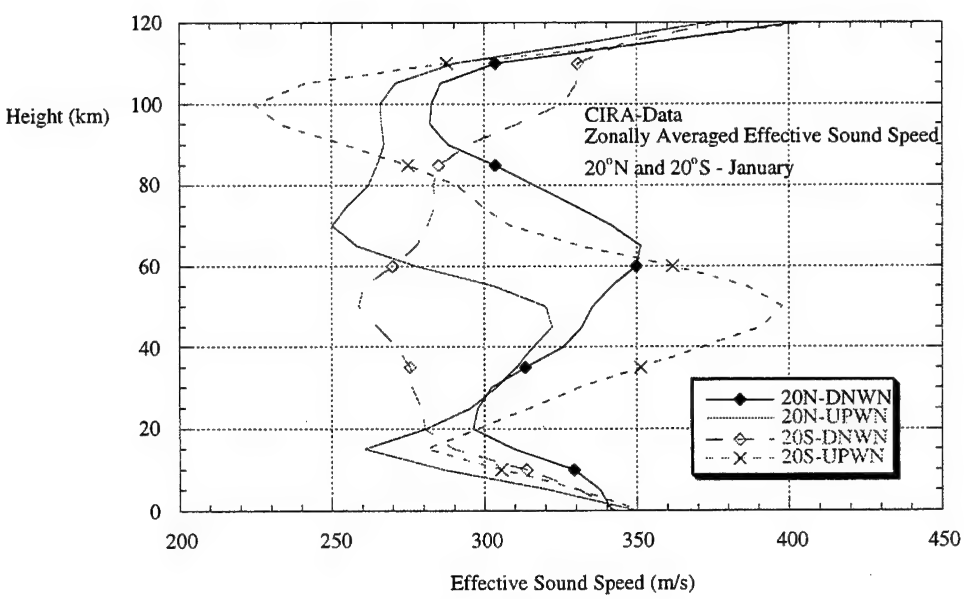

Figure 73b. Zonally averaged effective sound speed as a function of height during January at latitudes 20°N and 20°S. DNWN denotes downwind propagation and UPWN upwind propagation. [Figure constructed based on the *CIRA* (1986) data set.]

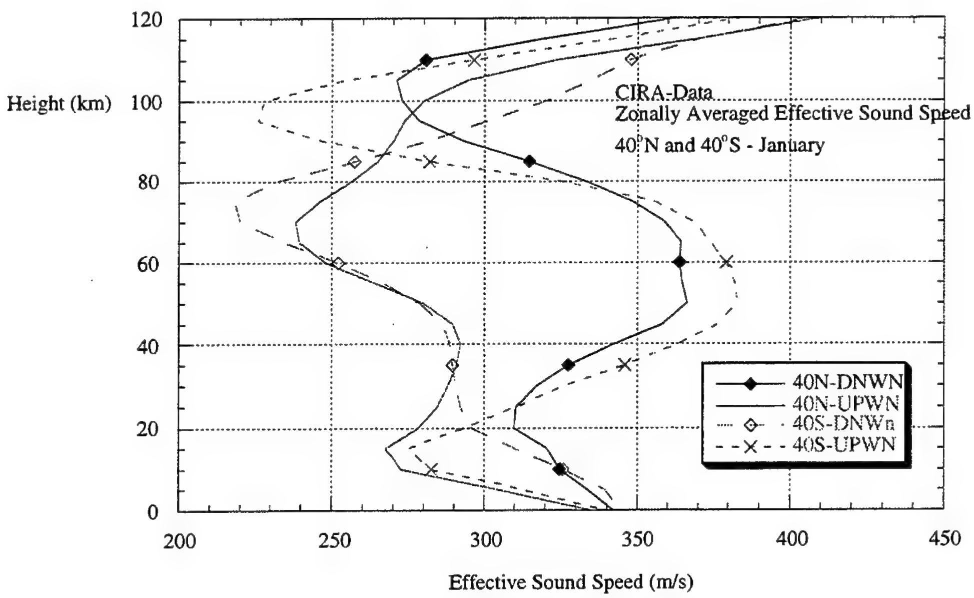

Figure 73c. Zonally averaged effective sound speed as a function of height during January at latitudes 40°N and 40°S. DNWN denotes downwind propagation and UPWN upwind propagation. [Figure constructed based on the *CIRA* (1986) data set.]

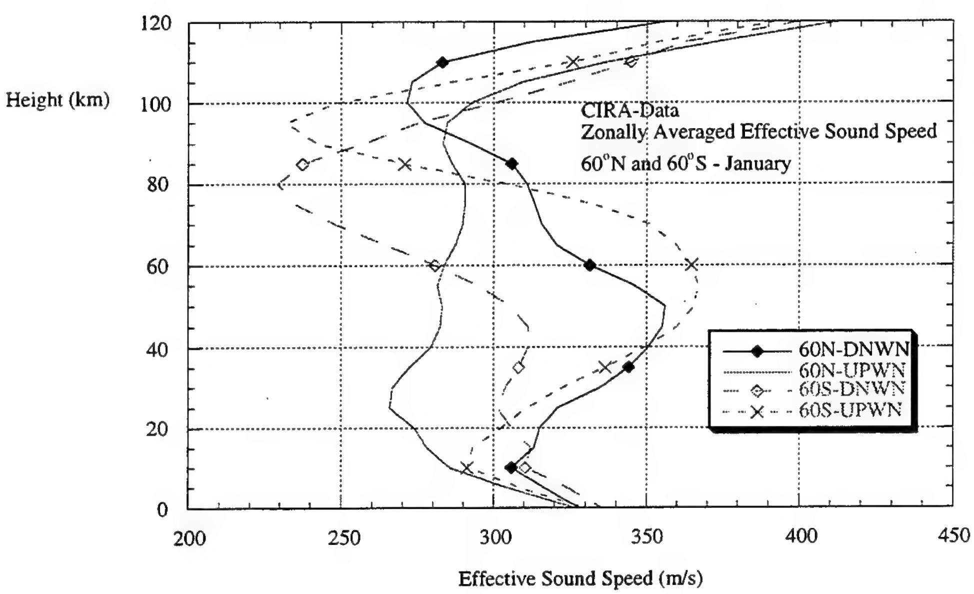

Figure 73d. Zonally averaged effective sound speed as a function of height during January at latitudes 60°N and 60°S. DNWN denotes downwind propagation and UPWN upwind propagation. [Figure constructed based on the *CIRA* (1986) data set.]

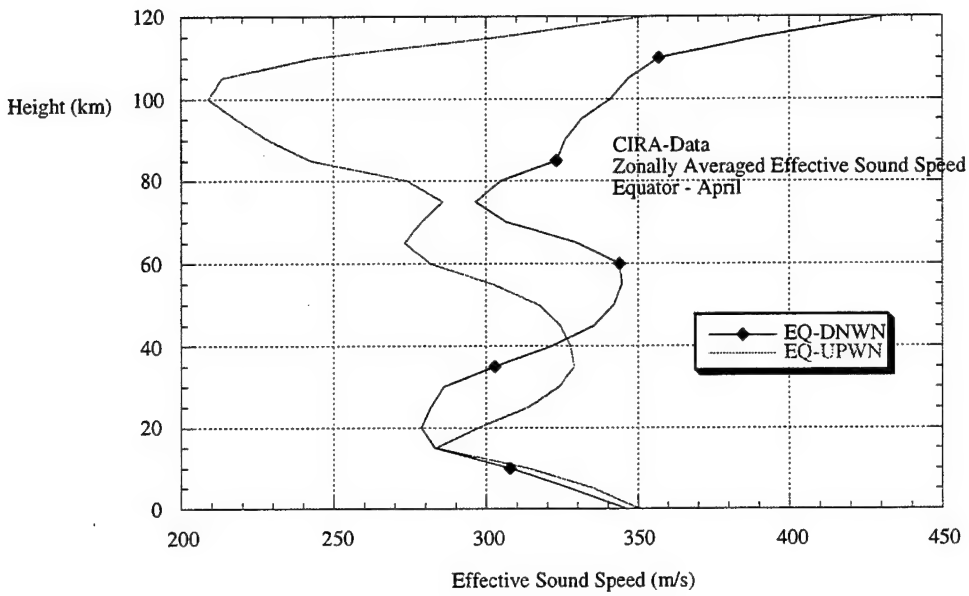

Figure 74a. Zonally averaged effective sound speed as a function of height during April at the equator. [Figure constructed based on the *CIRA* (1986) data set.]

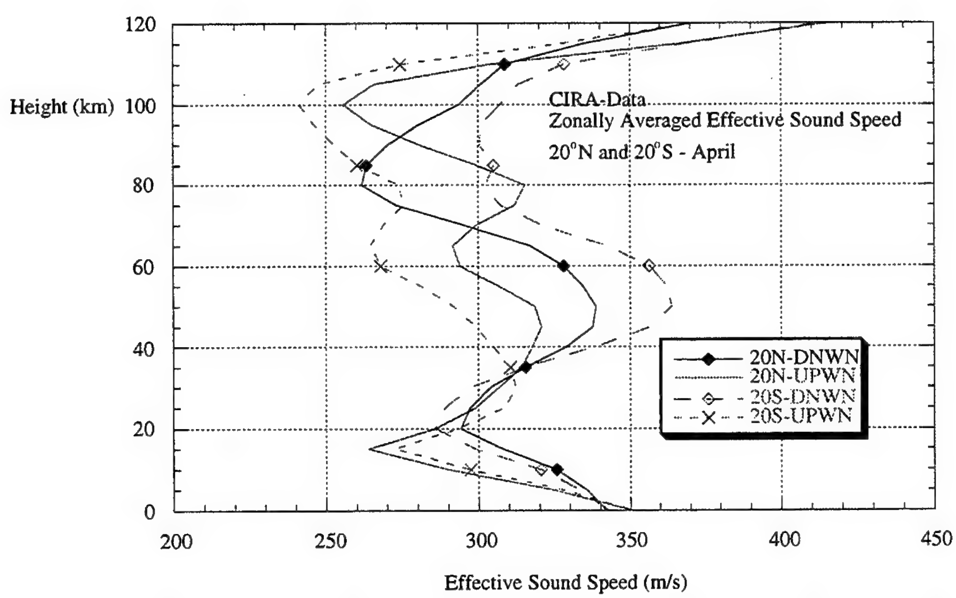

Figure 74b. Zonally averaged effective sound speed as a function of height during April at latitudes 20°N and 20°S. DNWN denotes downwind propagation and UPWN upwind propagation. [Figure constructed based on the *CIRA* (1986) data set.]

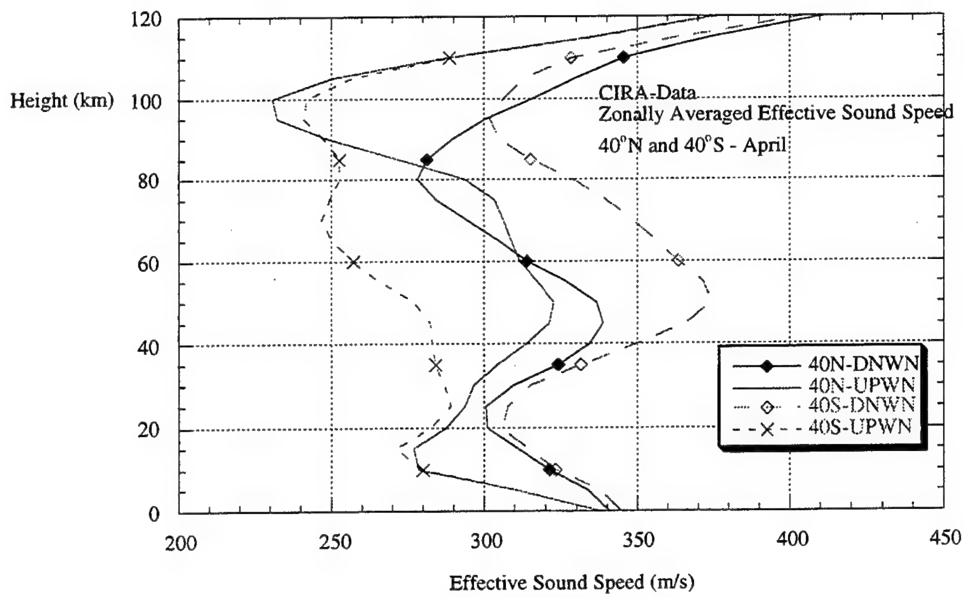

Figure 74c. Zonally averaged effective sound speed as a function of height during April at latitudes 40°N and 40°S. DNWN denotes downwind propagation and UPWN upwind propagation. [Figure constructed based on the *CIRA* (1986) data set.]

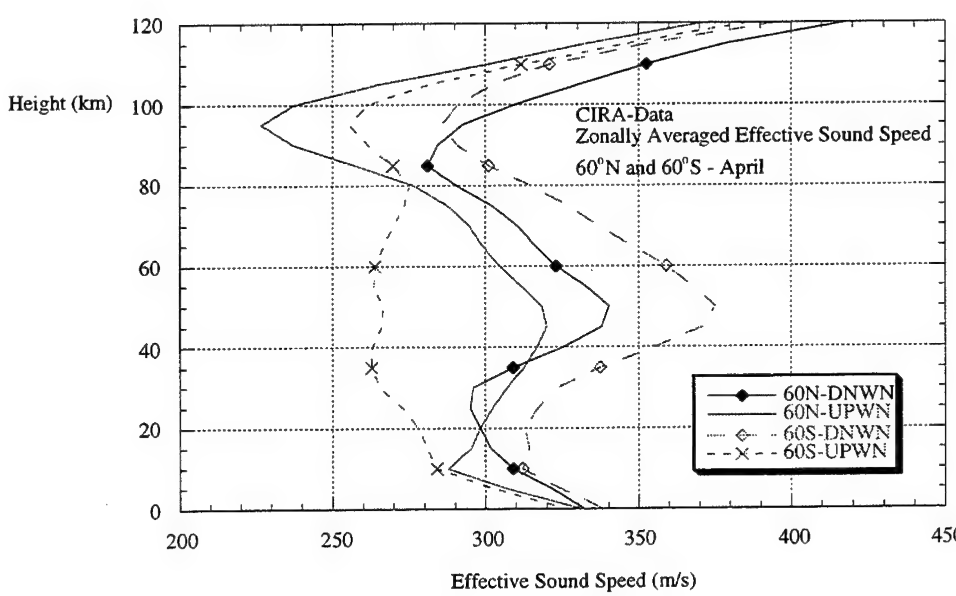

Figure 74d. Zonally averaged effective sound speed as a function of height during April at latitudes 60°N and 60°S. DNWN denotes downwind propagation and UPWN upwind propagation. [Figure constructed based on the *CIRA* (1986) data set.]

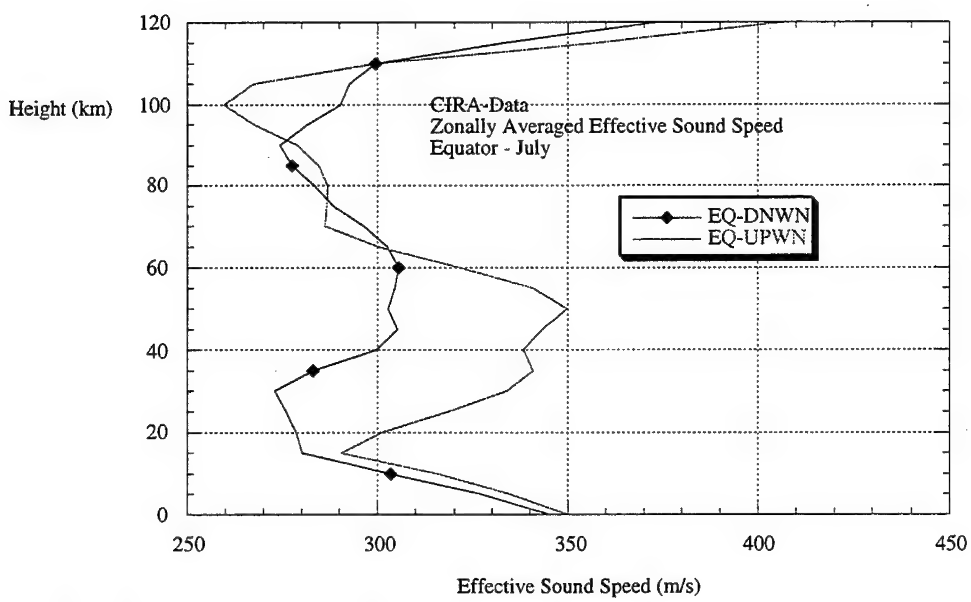

Figure 75a. Zonally averaged effective sound speed as a function of height during July at the equator. [Figure constructed based on the *CIRA* (1986) data set.]

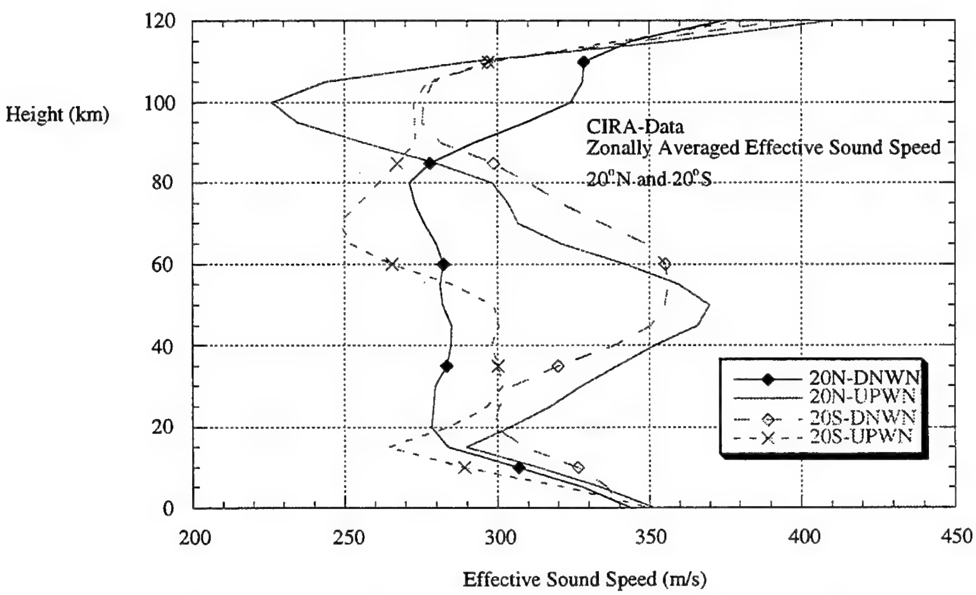

Figure 75b. Zonally averaged effective sound speed as a function of height during July at latitudes 20°N and 20°S. DNWN denotes downwind propagation and UPWN upwind propagation. [Figure constructed based on the *CIRA* (1986) data set.]

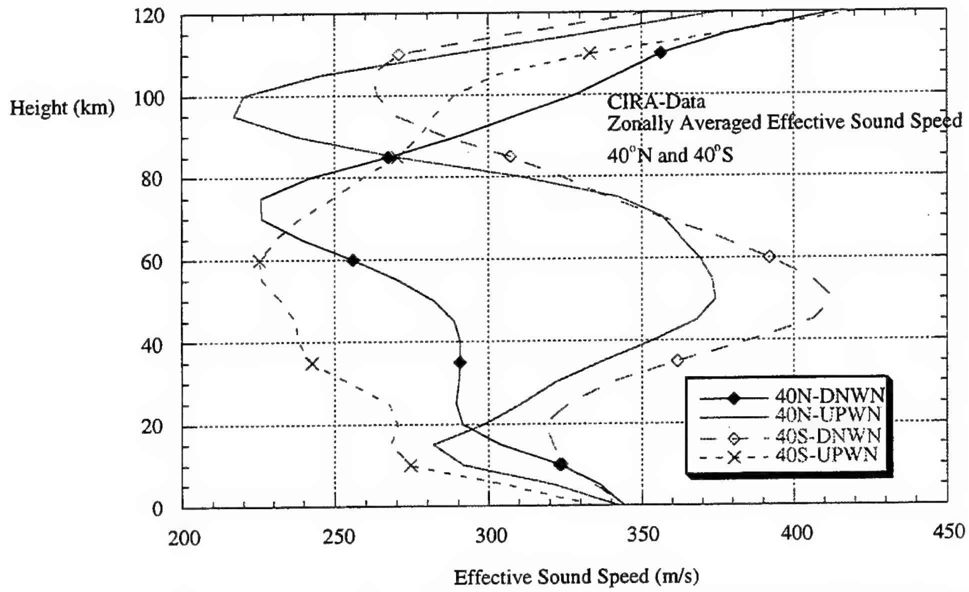

Figure 75c. Zonally averaged effective sound speed as a function of height during July at latitudes 40°N and 40°S. DNWN denotes downwind propagation and UPWN upwind propagation. [Figure constructed based on the *CIRA* (1986) data set.]

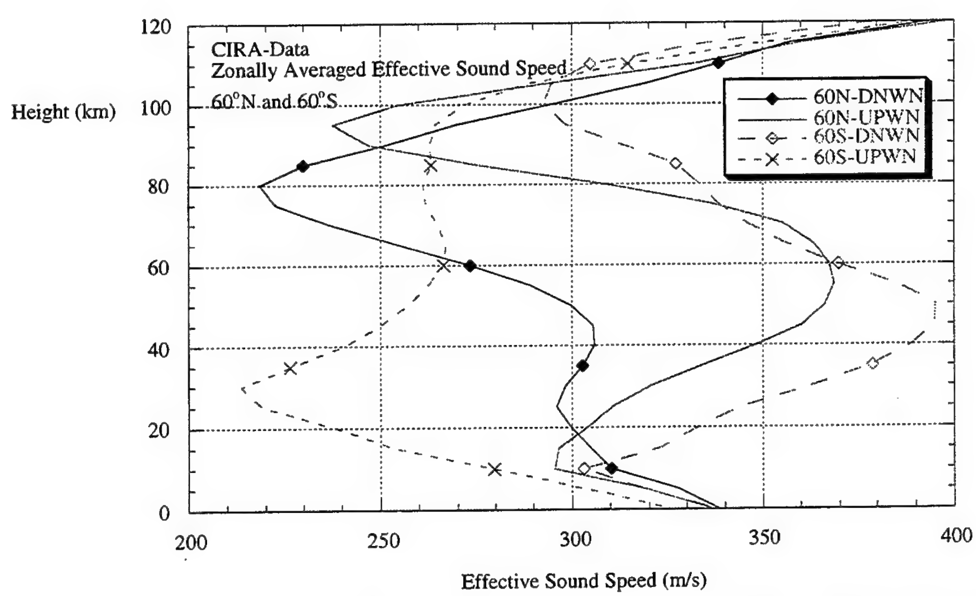

Figure 75d. Zonally averaged effective sound speed as a function of height during July at latitudes 60°N and 60°S. DNWN denotes downwind propagation and UPWN upwind propagation. [Figure constructed based on the *CIRA* (1986) data set.]

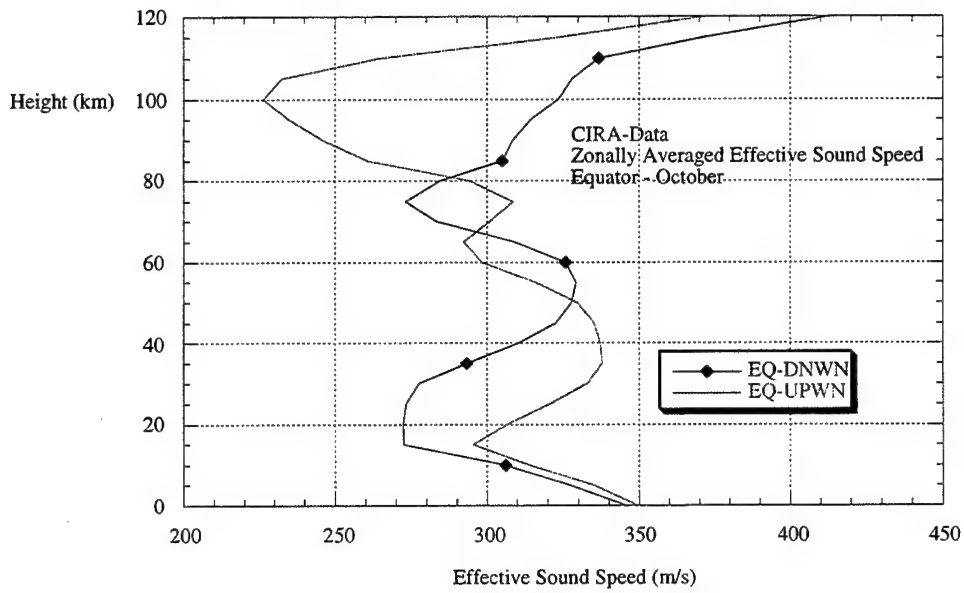

Figure 76a. Zonally averaged effective sound speed as a function of height during October at the equator. [Figure constructed based on the *CIRA* (1986) data set.]

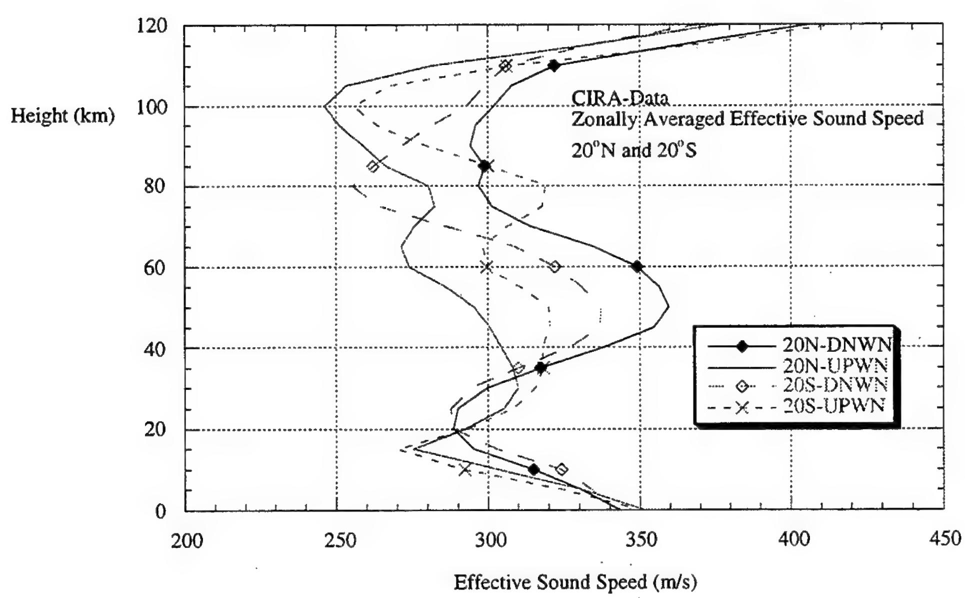

Figure 76b. Zonally averaged effective sound speed as a function of height during October at latitudes 20°N and 20°S. DNWN denotes downwind propagation and UPWN upwind propagation. [Figure constructed based on the *CIRA* (1986) data set.]

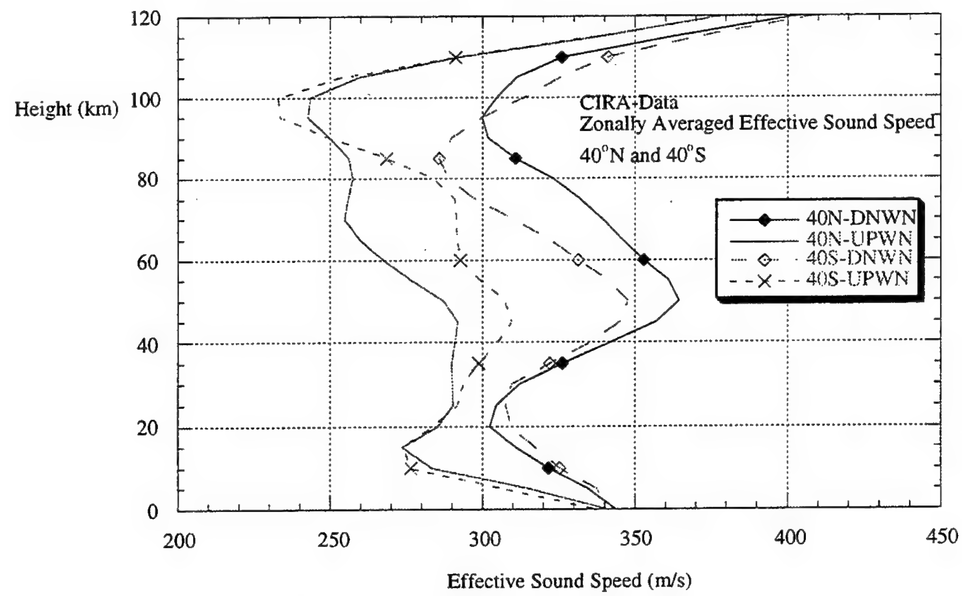

Figure 76c. Zonally averaged effective sound speed as a function of height during October at latitudes 40°N and 40°S. DNWN denotes downwind propagation and UPWN upwind propagation. [Figure constructed based on the *CIRA* (1986) data set.]

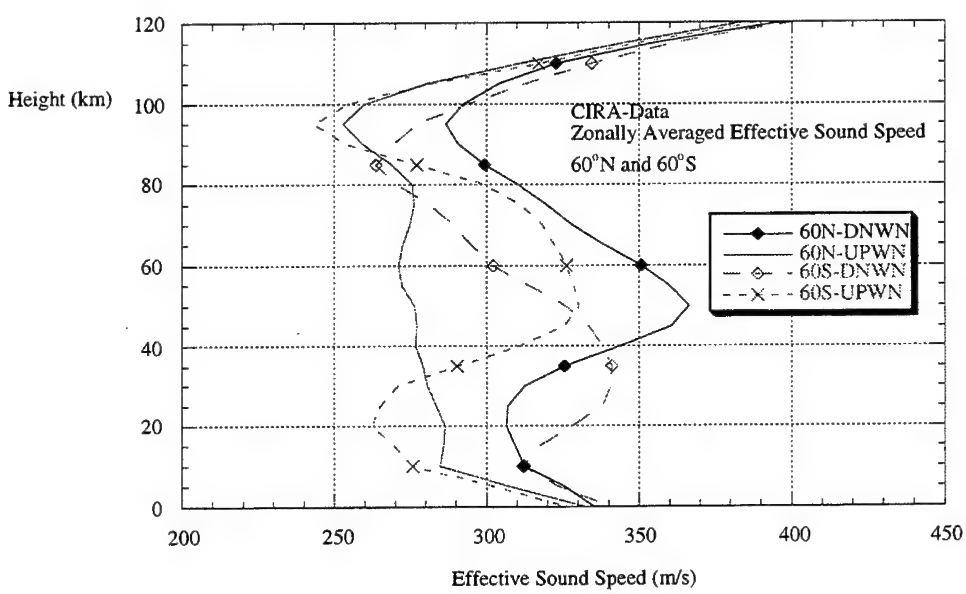

Figure 76d. Zonally averaged effective sound speed as a function of height during October at latitudes 60°N and 60°S. DNWN denotes downwind propagation and UPWN upwind propagation. [Figure constructed based on the *CIRA* (1986) data set.]

3.0 ATMOSPHERIC CLOUD COVER DATA

This section presents atmospheric cloud cover data which were obtained from the Lamont Doherty Environmental Observatory (LDEO) Climate Data Library which can be accessed on the Internet at: http://ingrid.ldgo.columbia.edu. The LDEO library contains a wide variety of earth science data: primarily climatological, oceanographic and atmospheric data sets. Representative examples of the types of atmospheric data sets which are available include: atmospheric composition (clouds and humidity) and earth radiative processes (heat flux and solar activity).

Cloud cover (and thickness) data are of interest in monitoring compliance with a CTBT because a potential violator might be tempted to conduct an atmospheric or underground test in geographical areas which are cloud covered a significant fraction of the time in order to minimize detection by satellite borne sensors.

In this section, climatological global cloud cover data are presented as a function of year-month. The data are presented in three subsections as contours of total cloud cover (or cloud fraction) where the cloud cover metric ranges from 0.0, corresponding to totally cloud free conditions, to 1.0 corresponding to 100% cloud cover.

• Subsection 3.1 presents climatological global cloud cover data available from the International Satellite Cloud Climatology Project (ISCCP) Solar Radiation and cloudiness. Available data include: mean cloudiness (fraction on a scale of 0 to 1) as a function of month, monthly solar radiation (W/m^2) and monthly cloud fraction for various select years.

The mean cloudiness data are available for twelve months: January through December. The data are organized by longitude from 178.75^{o}W to 178.75^{o}E in 2.5^{o} intervals (144 points) and by latitude from 88.75^{o}S to 88.75^{o}N in 2.5^{o} intervals (72 points).

• Subsection 3.2 presents climatological global cloud cover data available in the Atlas of Surface Marine Data 1944 [*daSilva, Young and Levitus* (1994)] (DASILVA SMD94) which provides data on various atmospheric and oceanographic parameters (e.g.,

air temperature (^{o}C), humidity (%), zonal winds, etc.) over both seasonal and yearly time frames.

The global cloud fraction data are available for twelve months and are organized by longitude from 0.5^{o}E to 0.5^{o}W in 0.5^{o} intervals (360 points) and by latitude from 89.5^{o}S to 89.5^{o}N (180 points).

• Subsection 3.3 presents cloud cover data available through the Oregon State University Climate Research Institute [e.g., *Esbensen and Kushnir* (1981)]. The institute provides monthly climatologies of atmospheric and oceanographic data sets (e.g., ocean heat flux and wind stress) as prepared by investigators at the Oregon State University and based on surface marine meteorological observations prepared by the National Climatic Center (NCC) and the *Berliand and Strokina* (1980) cloudiness atlas. Other data sets available from the institute include: surface wind speed, sea level pressure, sea surface temperature, sea/air temperature difference, air temperature, specific humidity, difference cloudiness, available solar radiation and various other data relevant to the earth's radiation budget.

The cloudiness data *per se* were taken from *Berliand and Strokina* (1980) which, in turn, "are based on a variety of sources, from regular ground observation networks over land and ocean to satellite observations. These were all integrated and presented on a global rectangular 5x5 degree grid for each of the 12 months and are given both as figures and as tabulated values. The authors claim a better representation of the distribution of cloudiness than achieved before, in particular over the ITCZ" [*Esbensen and Kushnir* (1981)].

Inspection of the ISCCP data in Subsection 3.1 (Figures 77 through 88) shows that in all months, the average cloud cover is significantly higher over the world's oceans than over land. The month of January is characterized by dense cloud cover (0.8-to-0.9) throughout the southern hemisphere in the approximate latitude range of 30^{o}S to 60^{o}S and in the ocean regions of the northern hemisphere in the latitude band 30^{o}N to 60^{o}N. This general pattern remains nearly the same in February. In March there is an additional area of

dense cloud cover (0.8-to-0.9) in the equatorial region: 0^{o}S to 20^{o}S and 30^{o}W to 60^{o}W, which begins to "weaken" (become less cloudy) in May. In June, July and August there is an almost continuous thin band of dense clouds in the latitude range 0^{o}N to 10^{o}N which extends around the entire circumference of the earth. The areas of high cloud cover in the northern and southern hemispheres are seen to persist. In addition, central Australia and Northern and Southern Africa are seen to experience very low average cloud cover (typically ≤ 0.2). The mean cloud cover in July and August is also characterized by two equatorial zones (0^{o}S to 20^{o}S) of high cloudiness: 60^{o}W to 90^{o}W and 0^{o}E to 15^{o}E with the overall global pattern much the same in November and December except that the equatorial high cloudiness region extending from 0^{o}E to 15^{o}E is reduced to an average level of 0.8.

Inspection of the data of *daSilva, Young and Levitus* (1994) in Subsection 3.2 (Figures 89 through 100) and the data of *Berliand and Strokina* (1980) in Subsection 3.3 (Figures 101 through 112) shows similar general patterns in cloud cover in that the ocean latitudinal regions 30^{o}S to 60^{o}S and 30^{o}N to 60^{o}N are by far the most cloudy in an average sense. However, there are of course differences in the details of the cloud cover data sets owing to the different data utilized, analysis procedures and time scale considered.

3.1 Monthly Global Mean Cloud Cover (or Fraction)

The data are based on the International Satellite Cloud Climatology Project (ISCCP): Solar Radiation and Cloudiness: Figures 77 through 88.

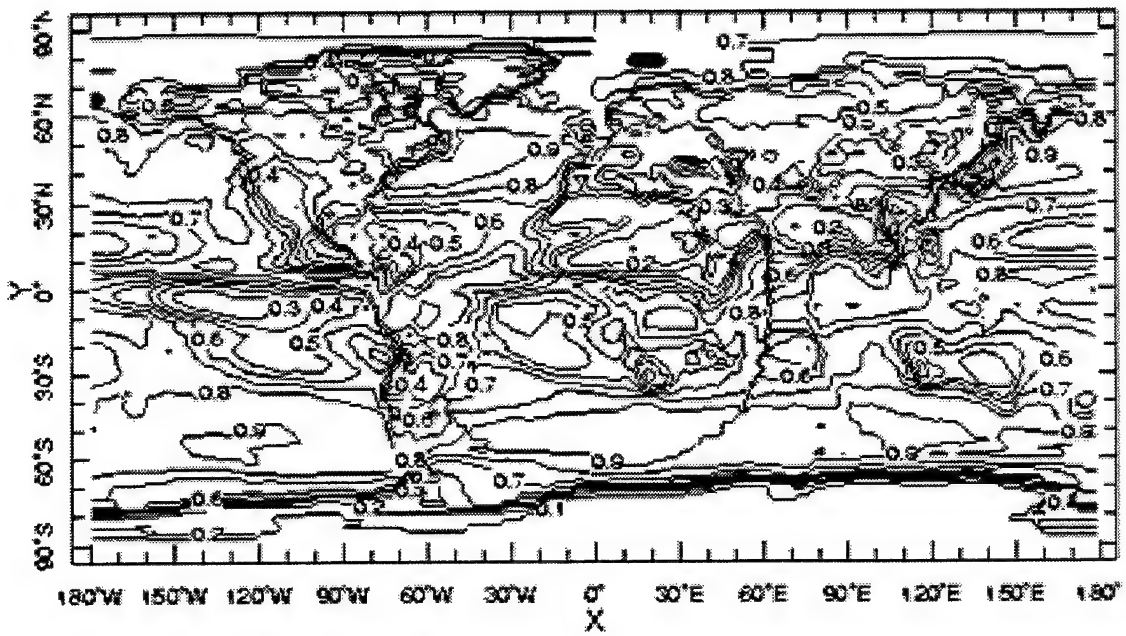

Figure 77. January mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.58255 ± 0.25043 - range: 0.00375 to 0.9825. [Data source: *ISCCP*]

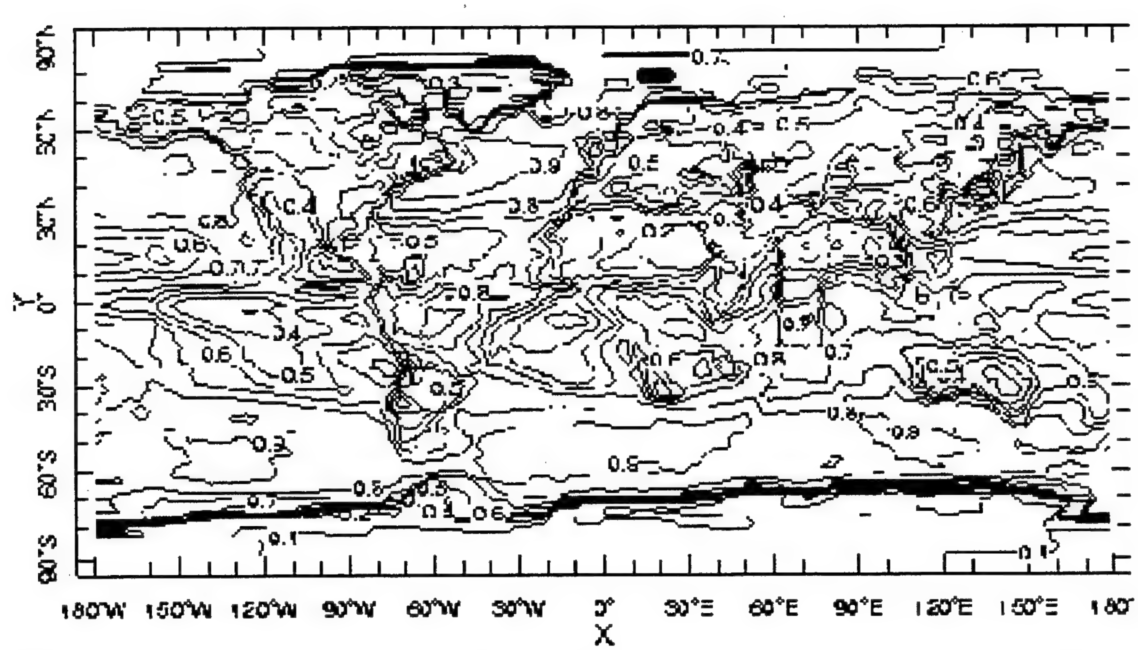

Figure 78. February mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.58693 ± 0.24831 - range: 0.02125 to 0.97375 - contour interval = 0.1. [Data source: *ISCCP*]

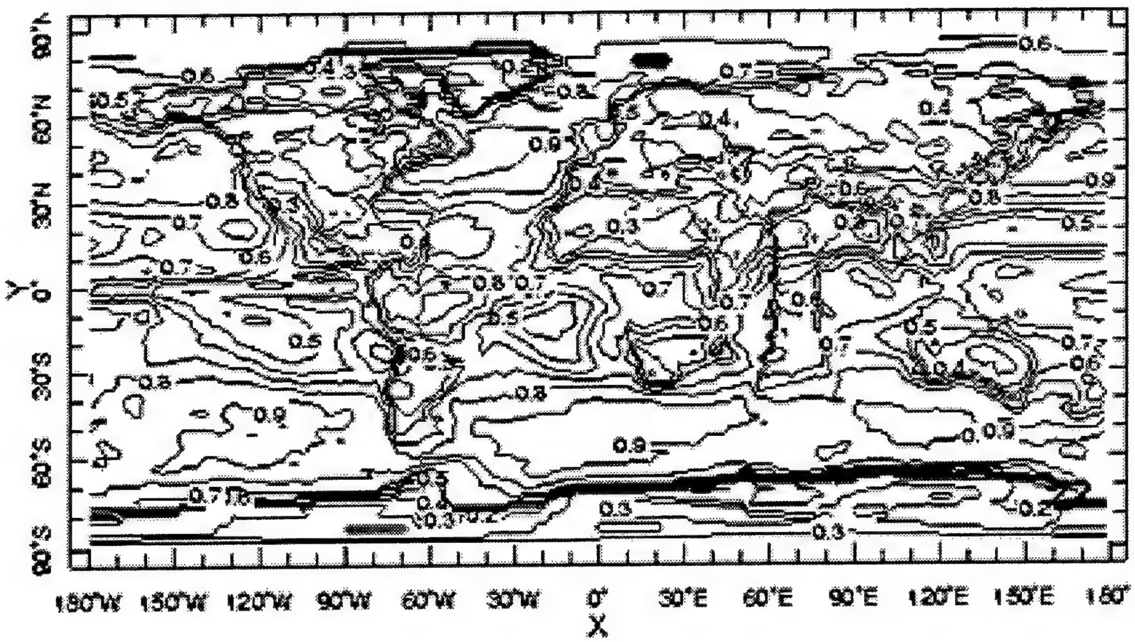

Figure 79. March mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.59928 ± 0.21935 - range: 0.056875 to 0.98438 - contour interval =0.1. [Data source: *ISCCP*]

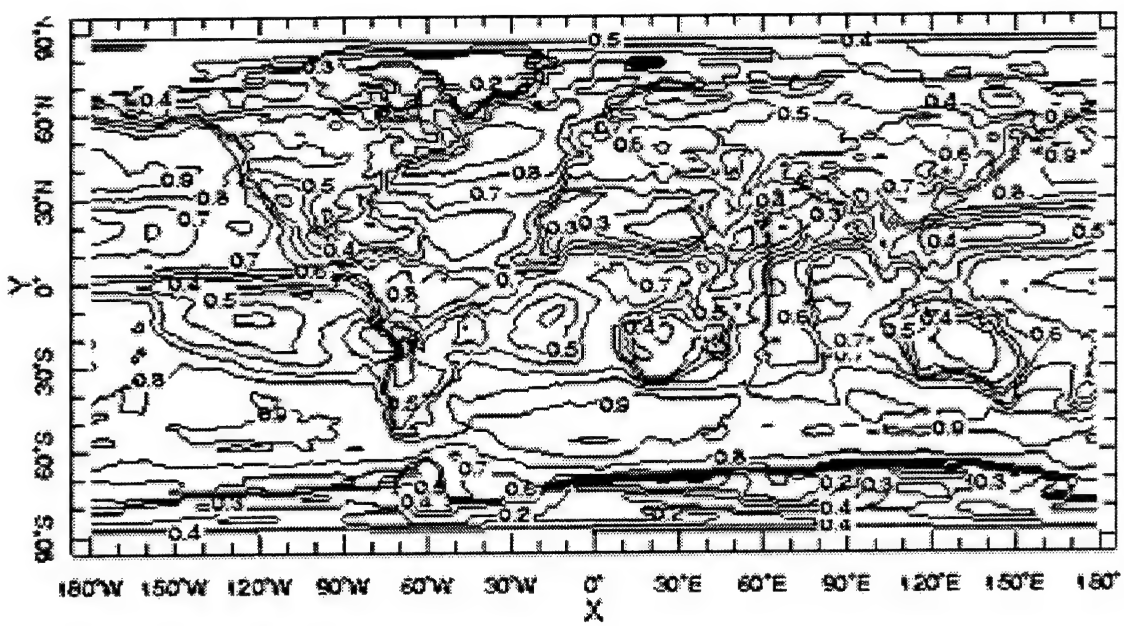

Figure 80. April mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.58864 ± 0.20759 - range 0.078125 to 0.975 - contour interval =0.1. [Data source: *ISCCP*]

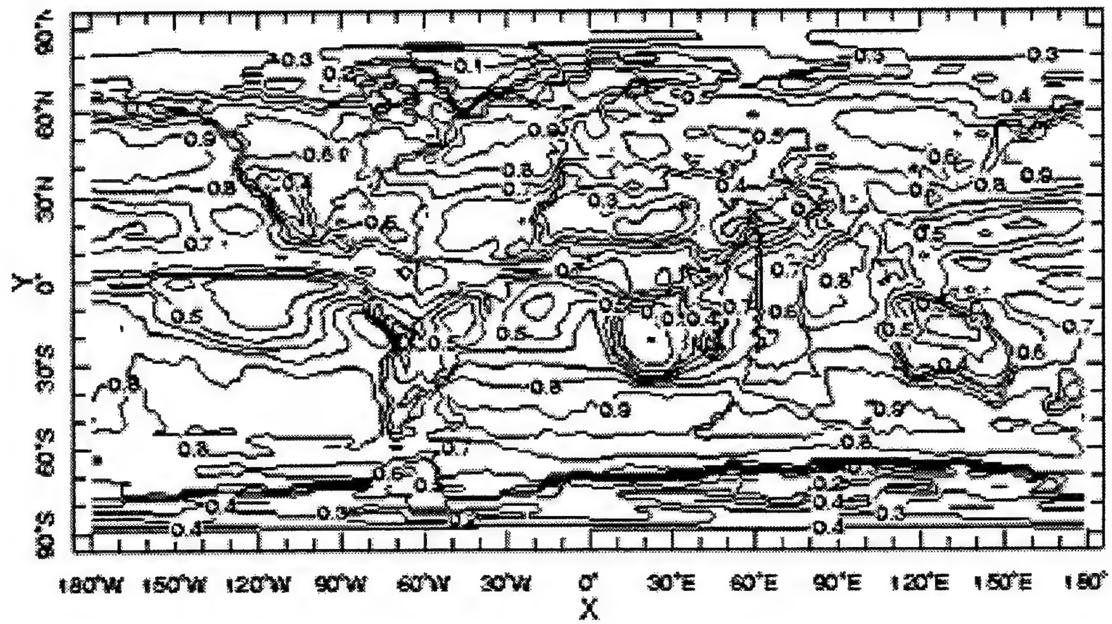

Figure 81. May mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.57541 ± 0.21454 - range 0.04625 to 0.98125 – contour interval = 0.1. [Data source: *ISCCP*]

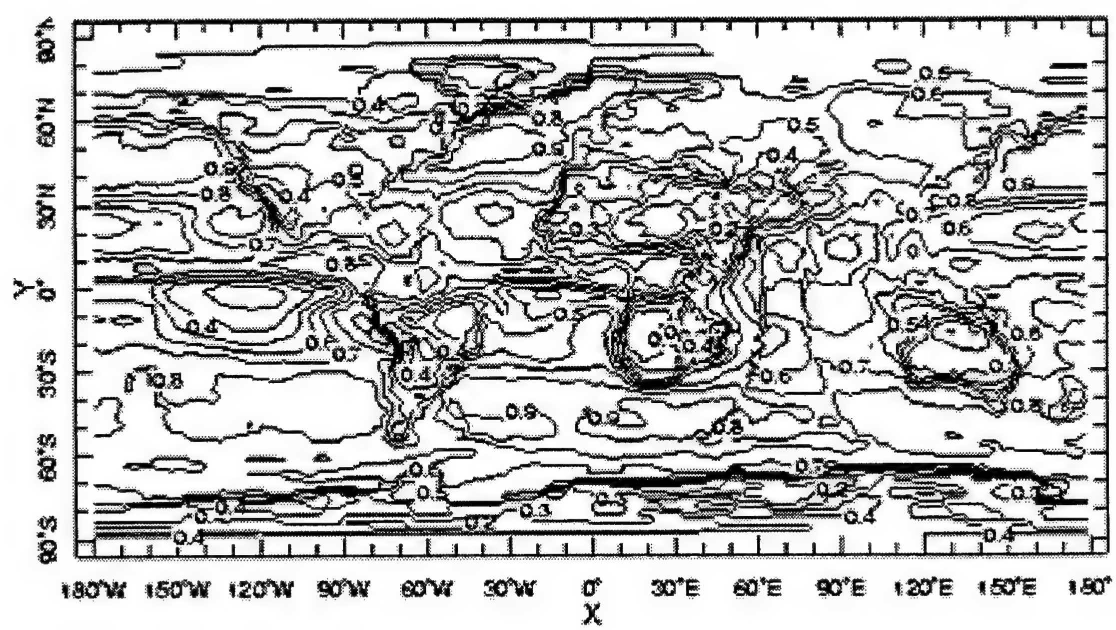

Figure 82. June mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.585 ± 0.20725 - range: 0.0325 to 0.99375 - contour interval = 0.1. [Data source: *ISCCP*]

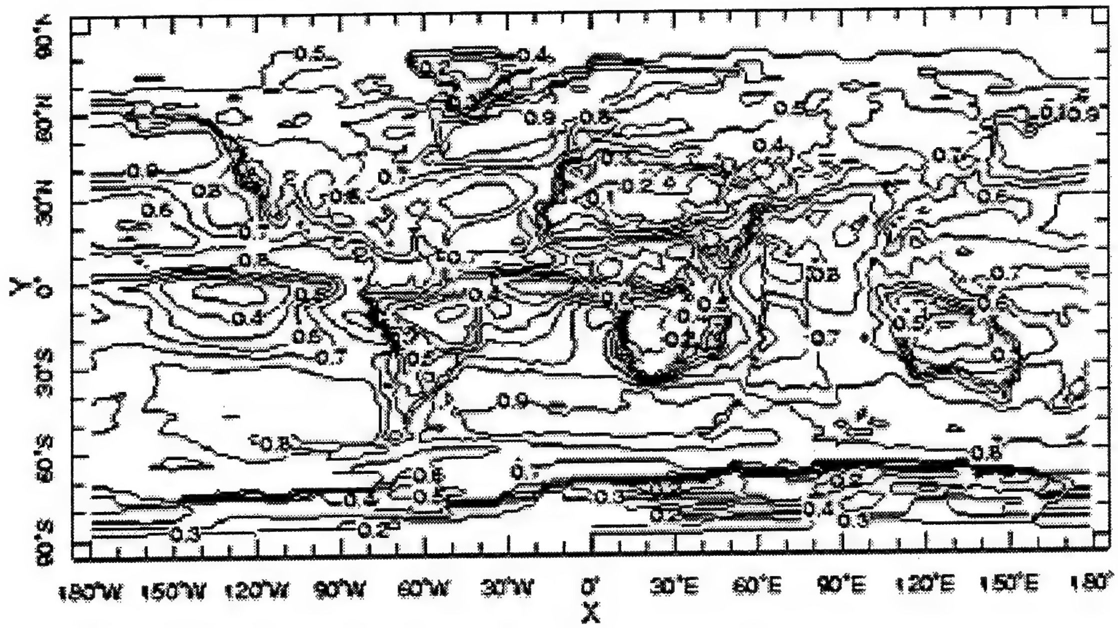

Figure 83. July mean global cloud cover (or cloud fraction) as a function of latitude and longitude: pont mean: 0.59425 ± 0.20886 - range: 0.013125 to 0.9925 - contour interval = 0.1. [Data source: *ISCCP*]

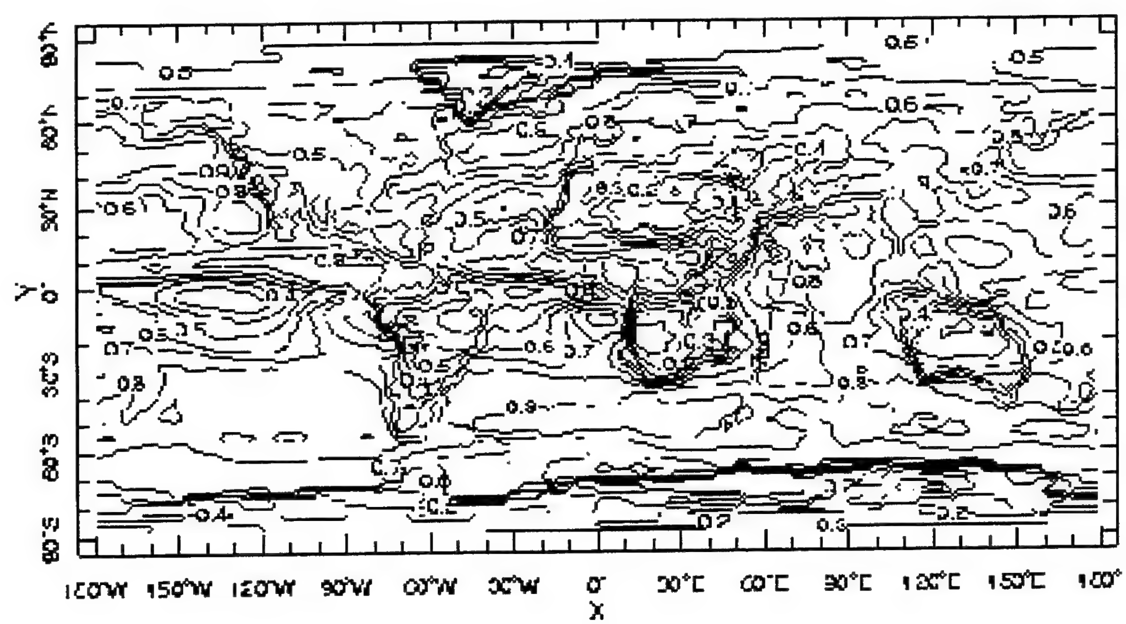

Figure 84. August mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.59843 ± 0.20945 - range: 0.011875 to 0.98937 - contour interval = 0.1. [Data source: *ISCCP*]

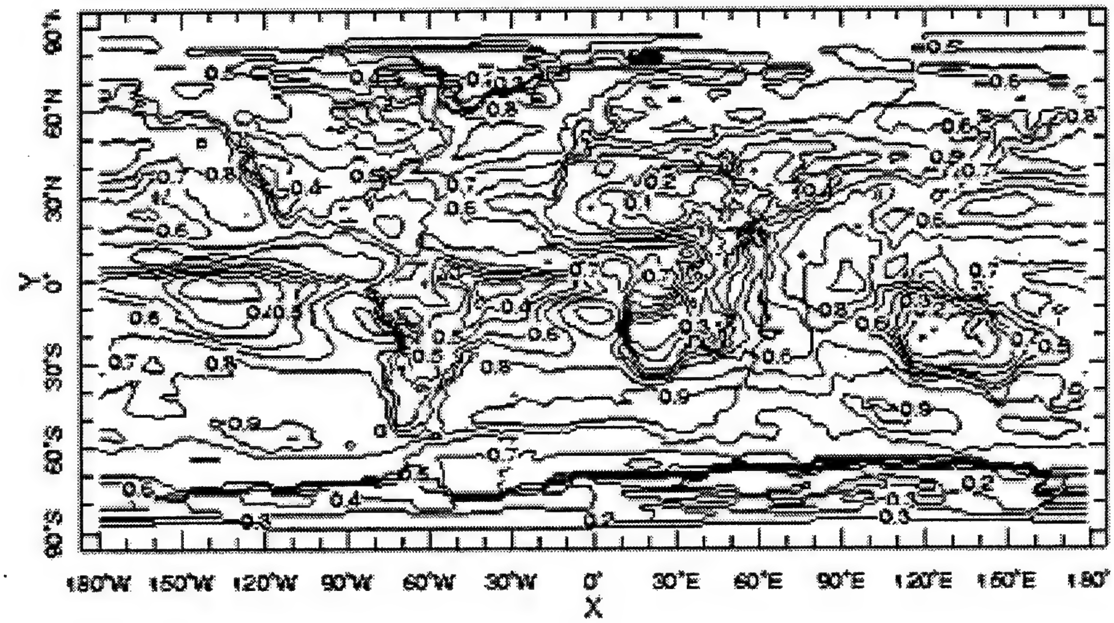

Figure 85. September mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.59599 ± 0.2065 - range: 0.02375 to 0.9651 - contour interval = 0.1. [Data source: *ISCCP*]

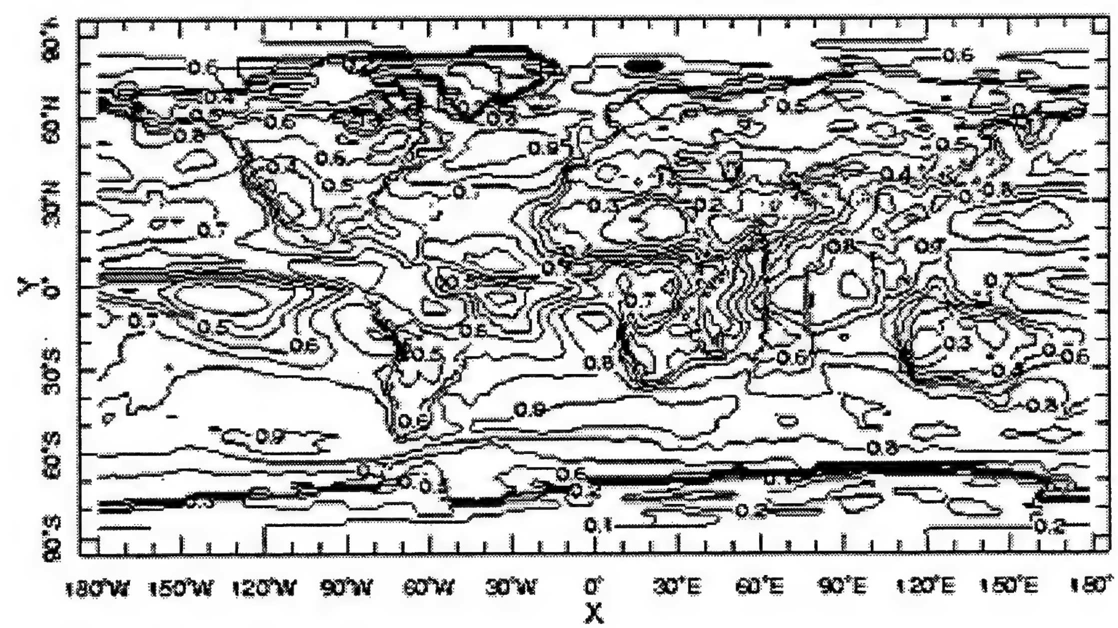

Figure 86. October mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.58745 ± 0.22433 - range: 0.040625 to 0.97125 - contour interval = 0.1. [Data source: *ISCCP*]

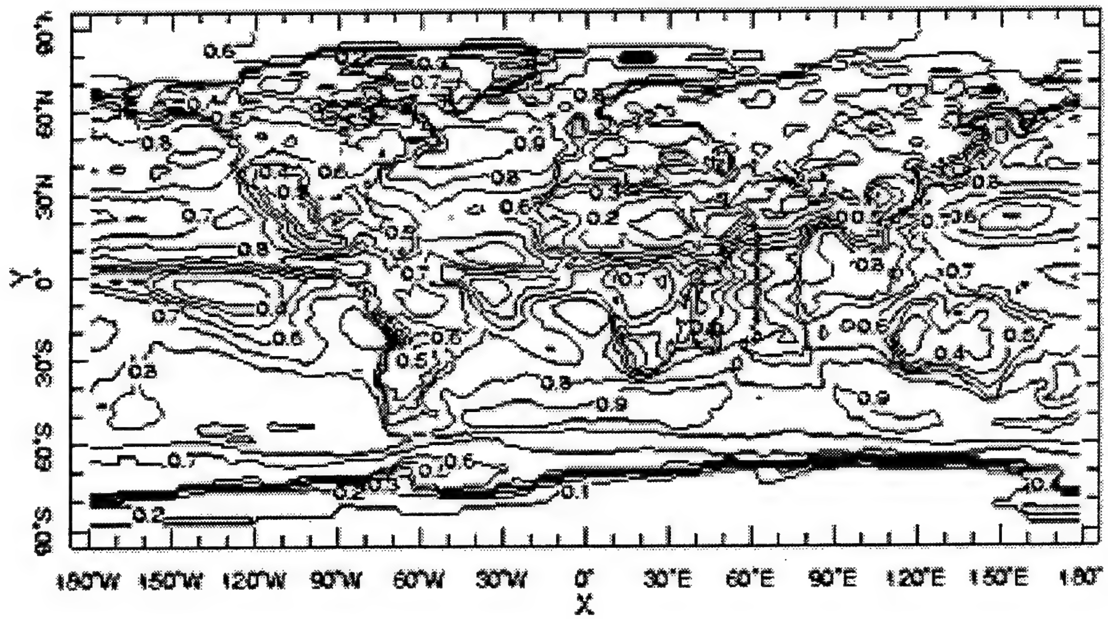

Figure 87. November mean global cloud cover (or cloud fraction) as a function of latitude and longitdue: point mean: 0.57947 $\pm$ 0.24184 - range: 0.00875 to 0.97688 - contour interval = 0.1. [Data source: *ISCCP*]

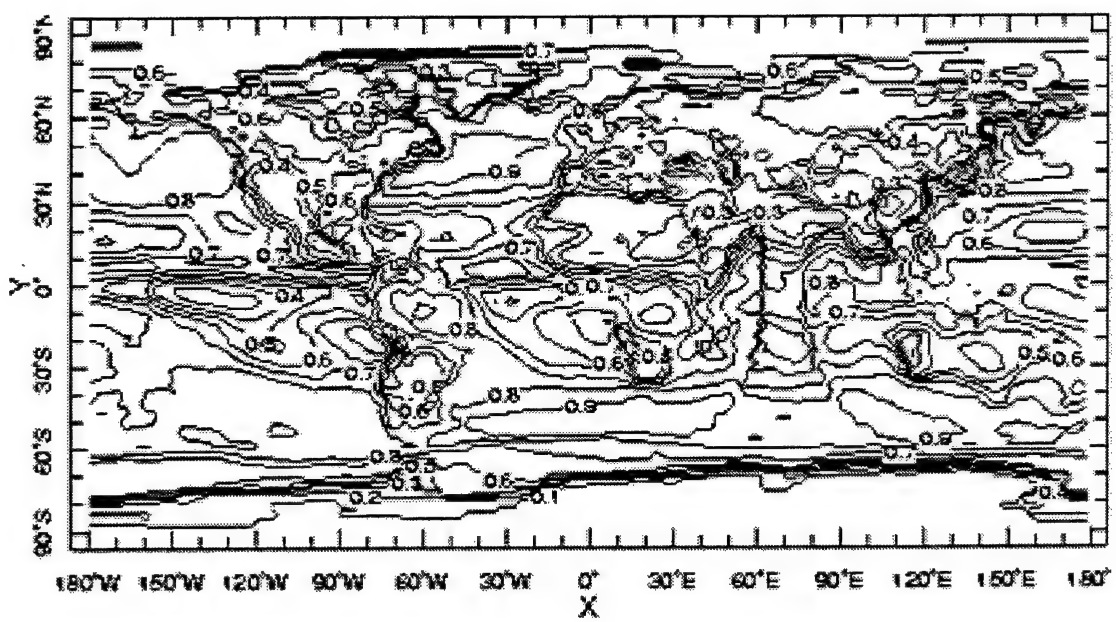

Figure 88. December mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.58113 $\pm$ 0.24272 range [0.0025 to 0.9775 - contour interval = 0.1. [Data source: *ISSCP*]

3.2 Monthly Global Mean Cloud Cover (or Fraction)

The data are based on the Atlas of Surface Marine Data - 1994 (DASILVA SMD94): Figures 89 through 100.

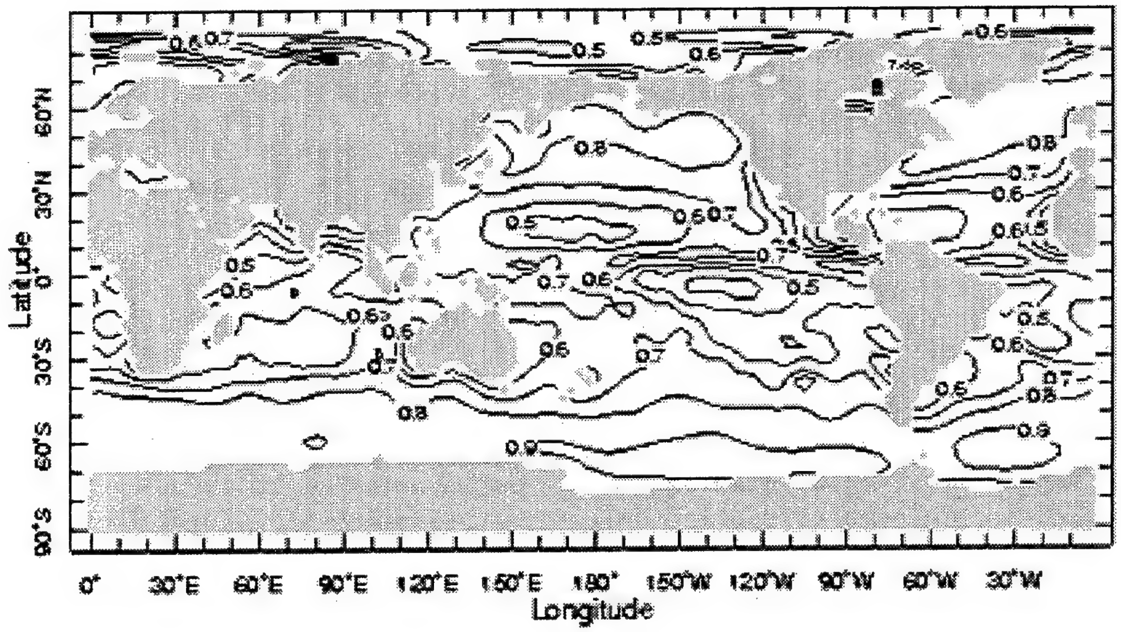

Figure 89. January mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.68938 ± 0.14395 - range: 0.1558 to 1.4032 - contour interval = 0.1. [Data source: *DASILVA SMD94*]

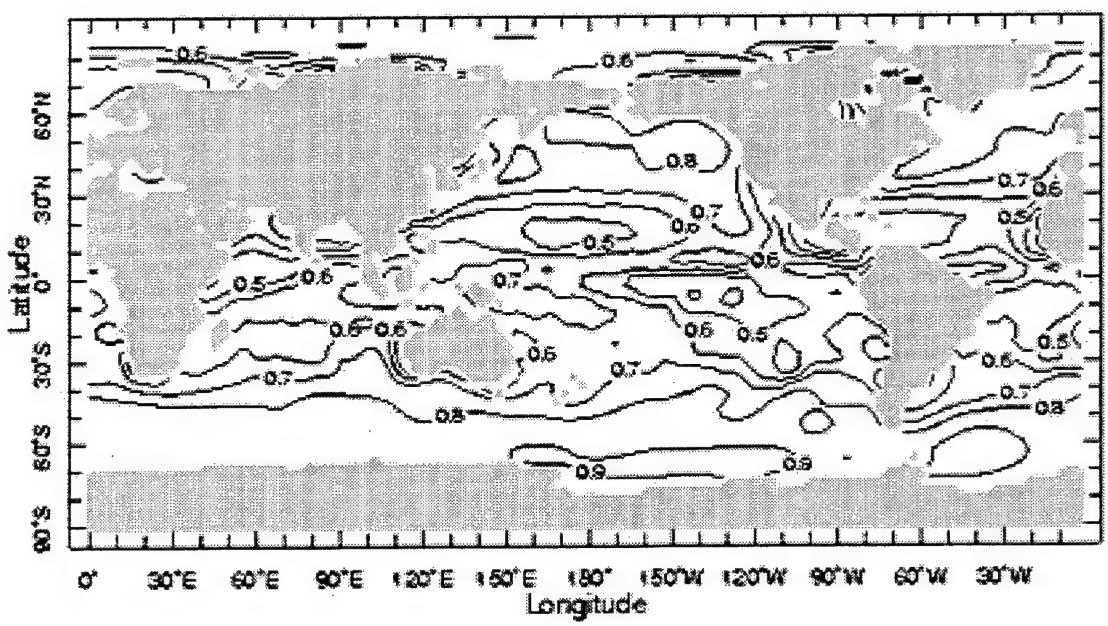

Figure 90. February mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.67987 ± 0.1475 - range: 0.10887 to 0.9694 - contour interval = 0.1. [Data source: *DASILVA SMD94*]

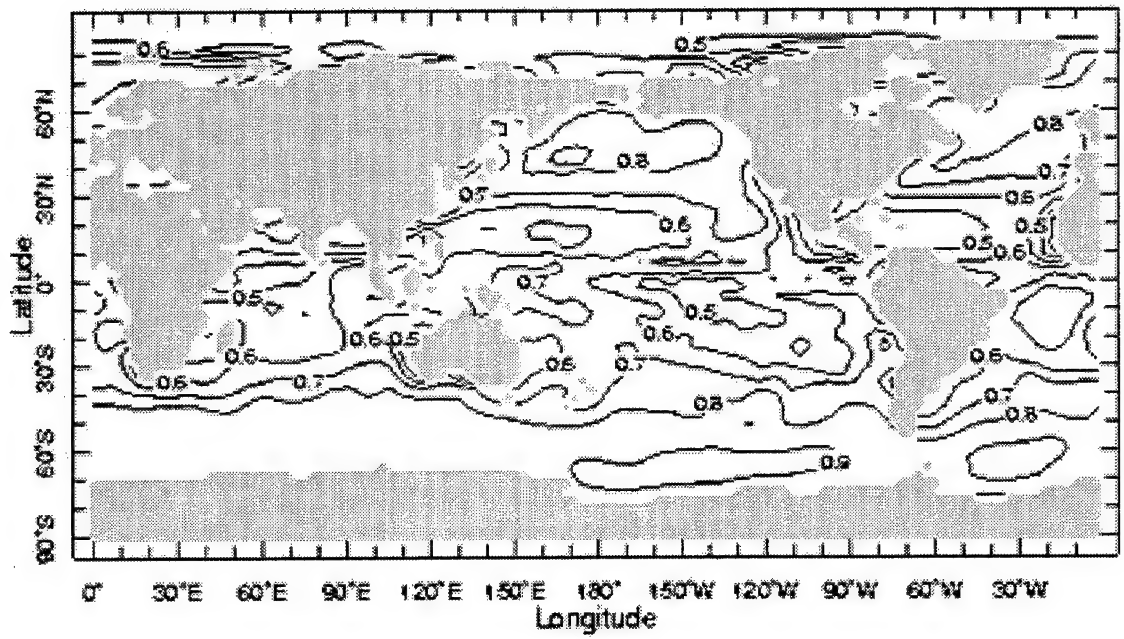

Figure 91. March mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.67572 ± 0.14886 - range: 0.1619 to 0.9326 - contour interval = 0.1. [Data source: *DASILVA SMD94*]

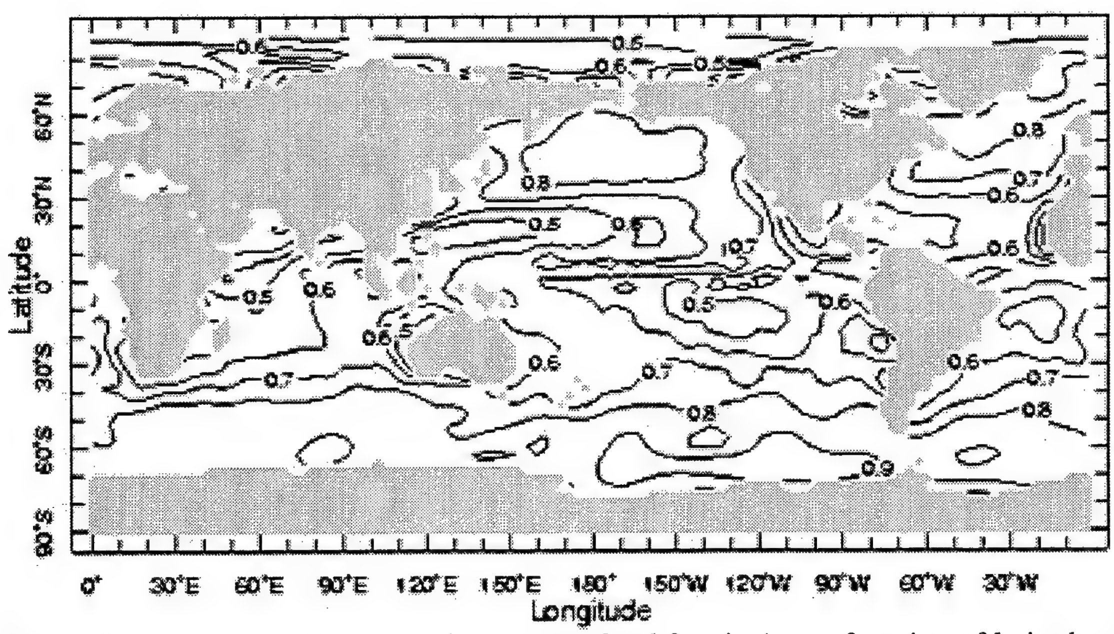

Figure 92. April mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.67738 ± 0.14784 - range: 0.1011 to 1.0477 - contour interval = 0.1. [Data source: *DASILVA SMD94*]

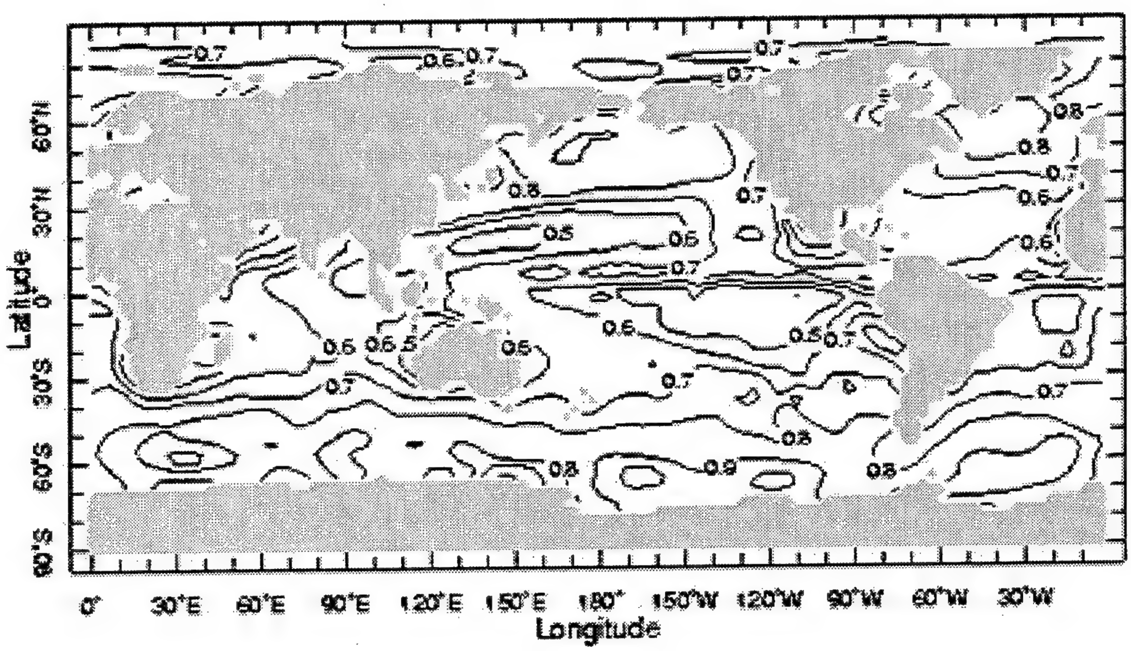

Figure 93. May mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.70255 ± 0.13592 - range: 0.1297 to 1.0408 - contour interval = 0.1. [Data source: *DASILVA SMD94*]

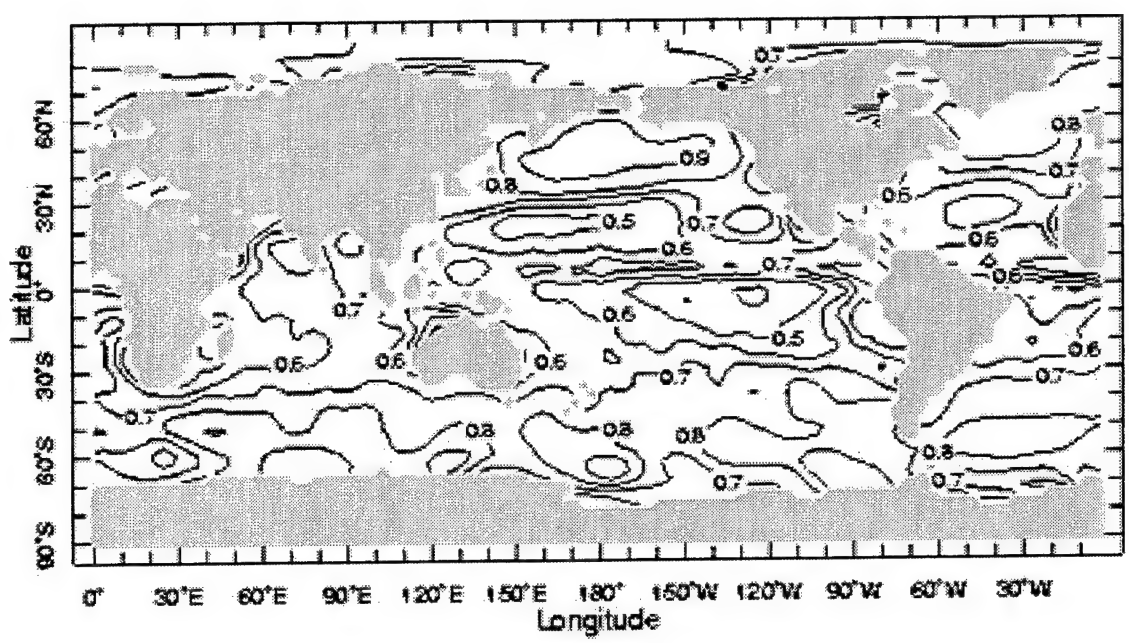

Figure 94. June mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.70399 ± 0.13107 - range: 0.0872 to 0.998 - contour interval = 0.1. [Data source: *DASILVA SMD94*]

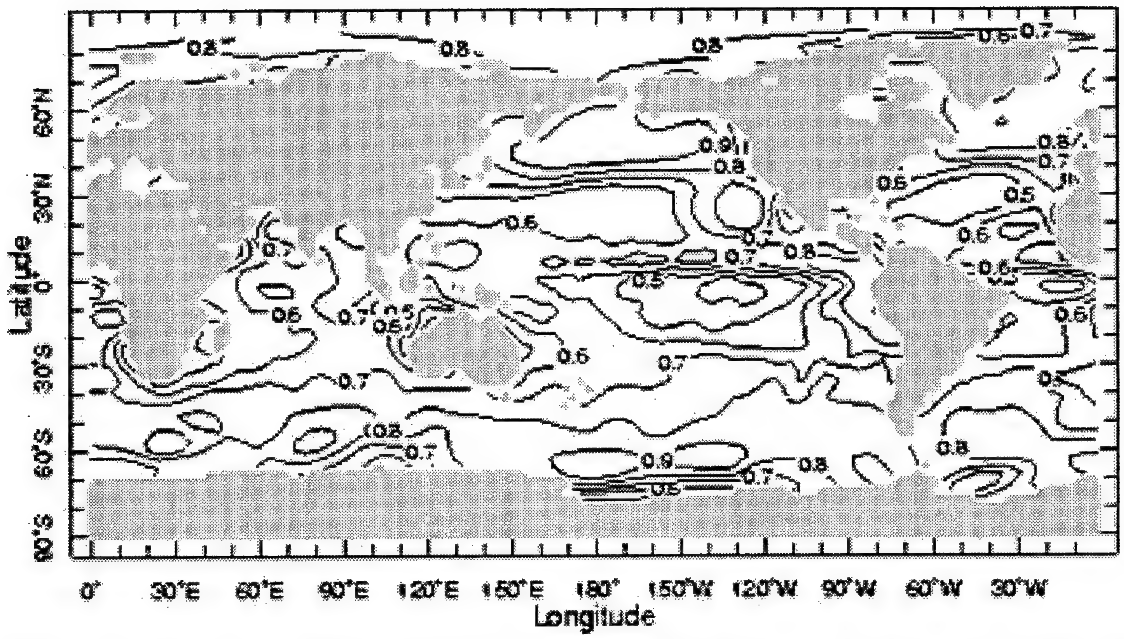

Figure 95. July mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.70399 ± 0.13107 - range: 0.0872 to 0.998 - contour interval = 0.1. [Data source: *DASILVA SMD94*]

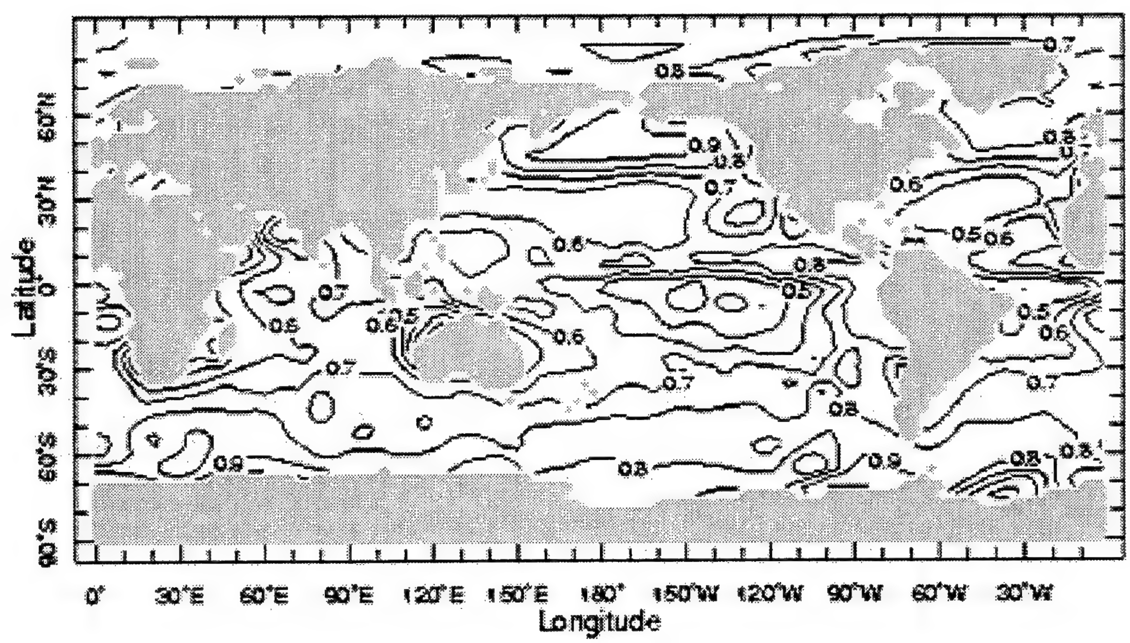

Figure 96. August mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.71065 ± 0.13901 - range: 0.0506 to 1.0208 - contour interval = 0.1. [Data source: *DASILVA SMD94*]

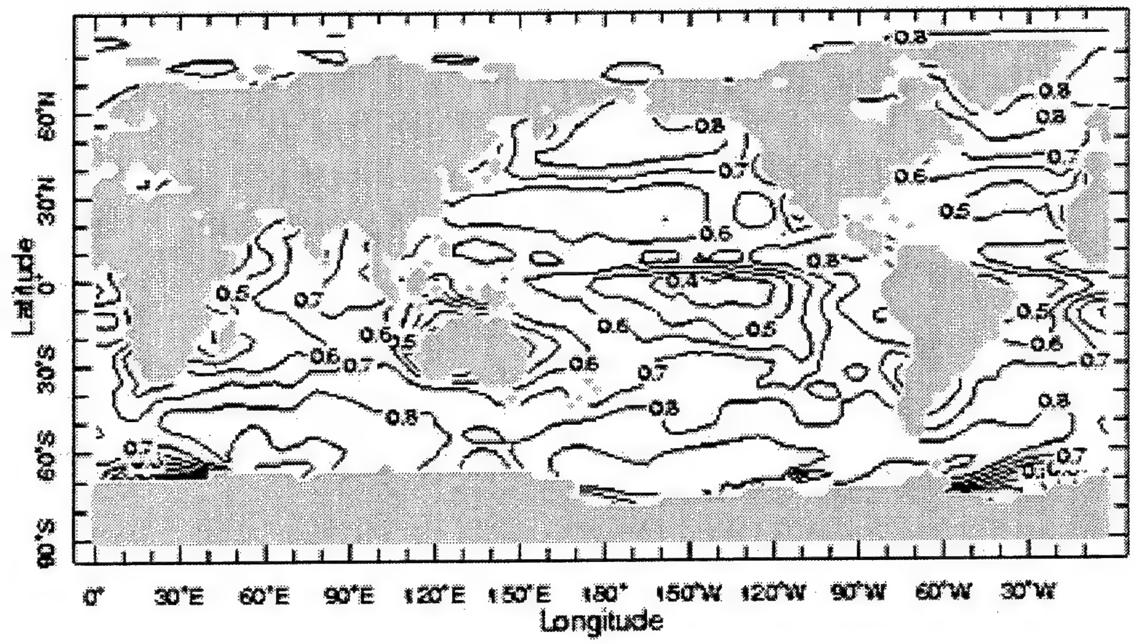

Figure 97. September mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.70305 ± 0.14677 - range: 0.0534 to 0.9941 - contour interval = 0.1. [Data source: *DASILVA SMD94*]

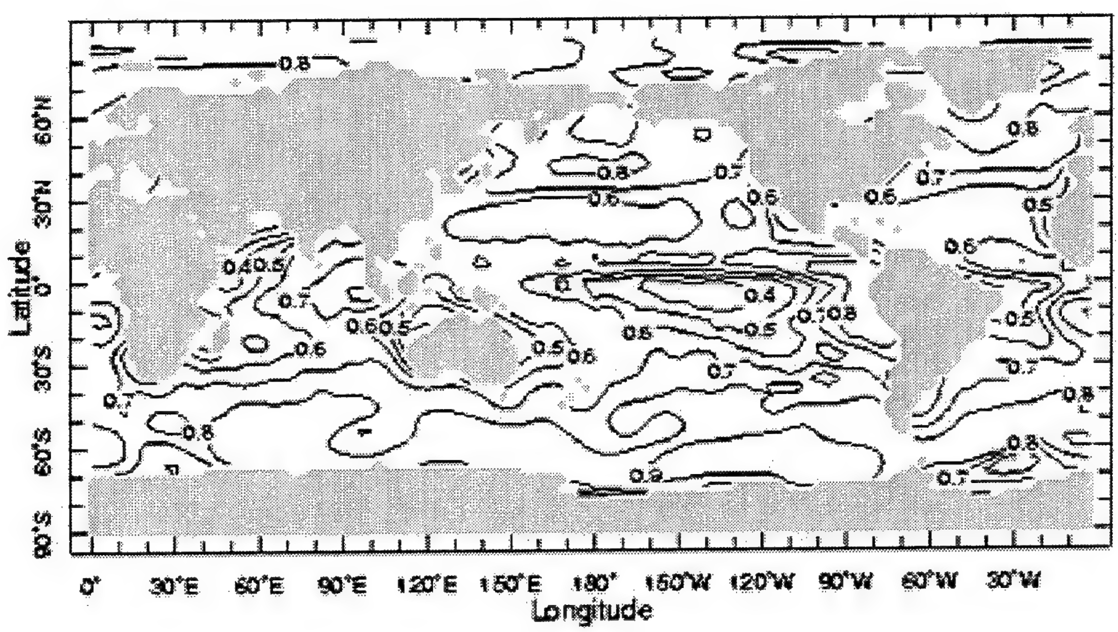

Figure 98. October mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.70287 ± 0.13345 - range: 0.0621 to 0.9712 - contour interval = 0.1. [Data source: *DASILVA SMD94*]

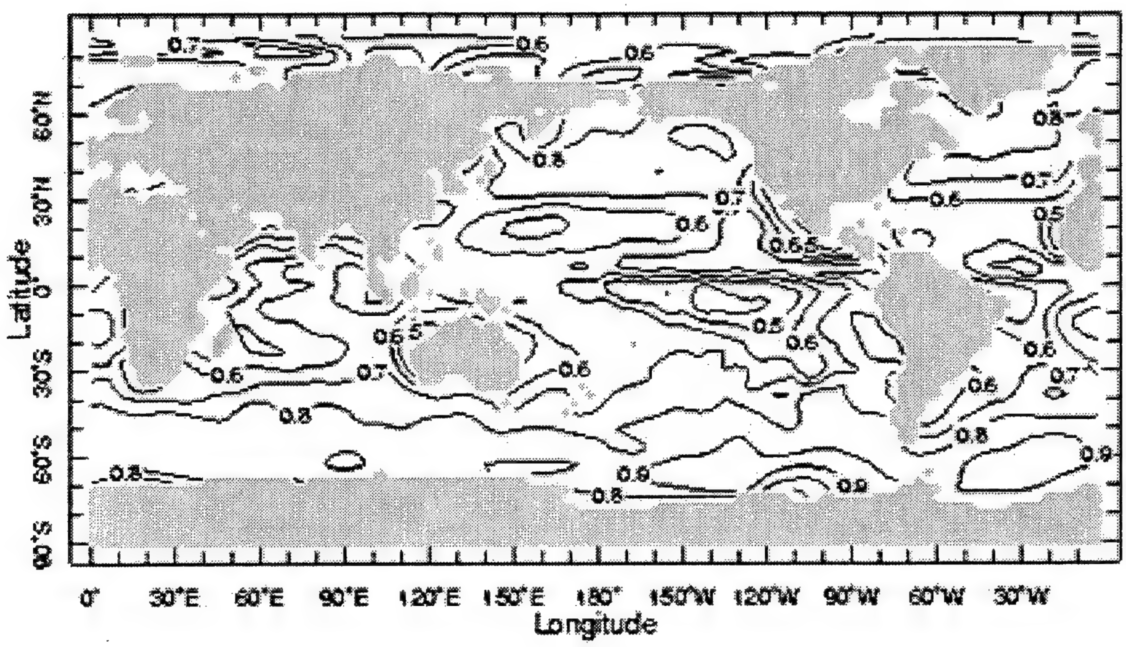

Figure 99. November mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.70003 ± 0.13727 - range: 0.123 to 0.9935 - contour interval = 0.1. [Data source: *DASILVA SMD94*]

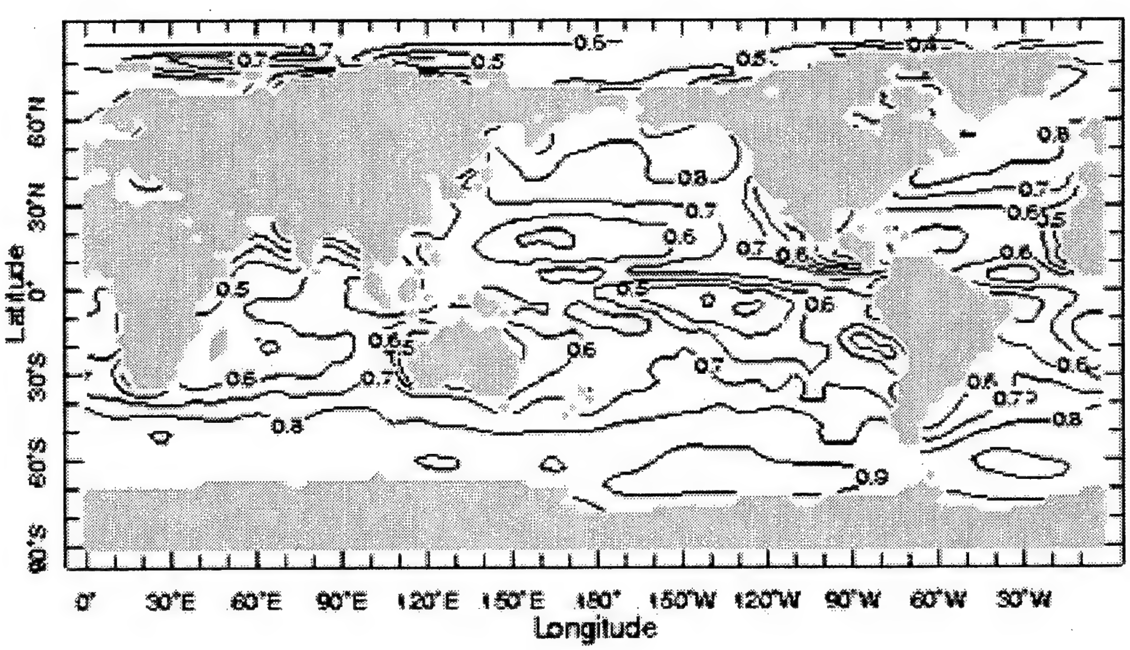

Figure 100. December mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.69824 ± 0.13704 - range: 0.1543 to 0.9432 - contour interval = 0.1. [Data source: *DASILVA SMD94*]

3.3. Monthly Global Mean Cloud Cover (or Fraction)

The data are based on the *Berliand and Strokina* (1980): Global Distribution of the Total Amound of Cloudiness: Figures 101 through 112.

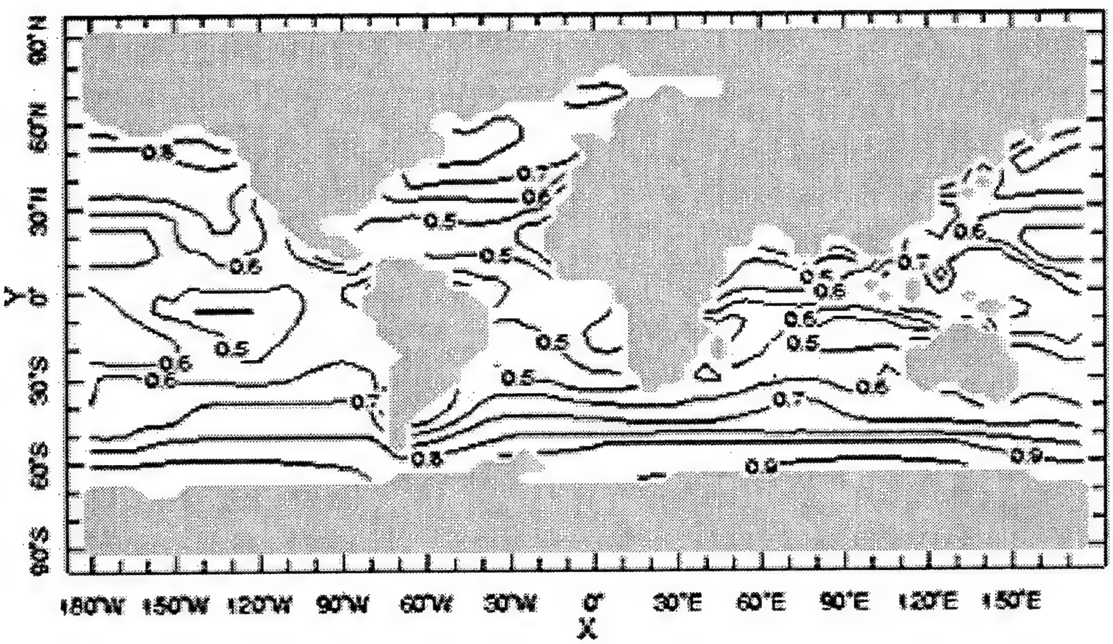

Figure 101. January mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.66109 ± 0.14437 - range: 0.218 to 0.942 - contour interval = 0.1. [Data source: *Berliand and Strokina* (1980) Cloudiness Atlas]

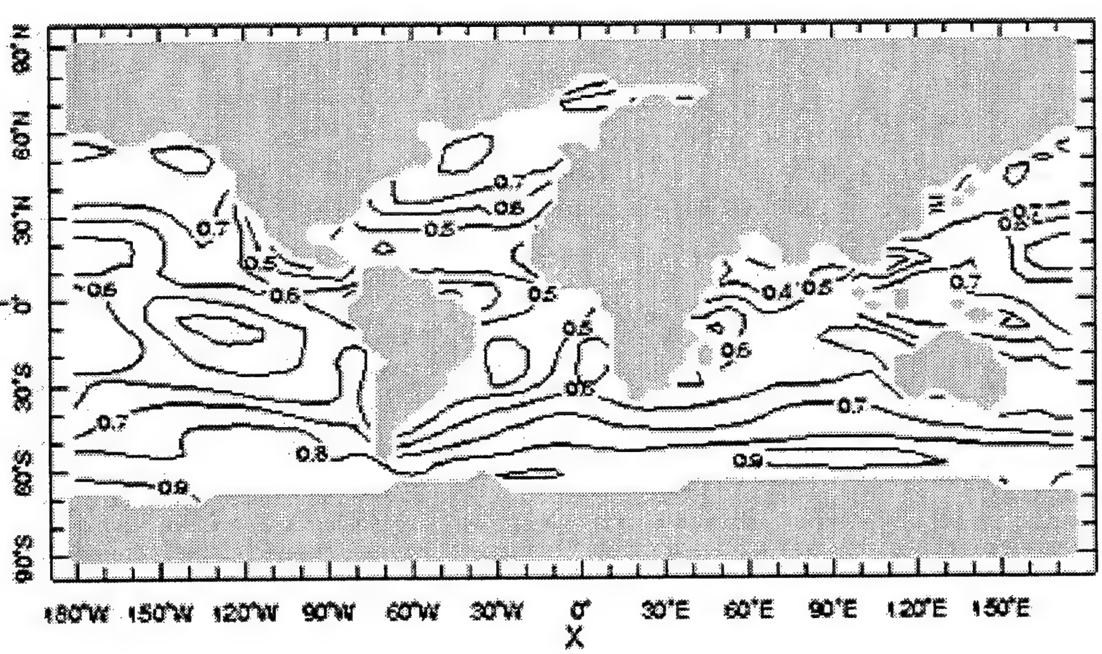

Figure 102. February mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.65221 ± 0.14382 - range: 0.207 to 0.926 - contour interval = 0.1. [Data source: *Berliand and Strokina* (1980) Cloudiness Atlas]

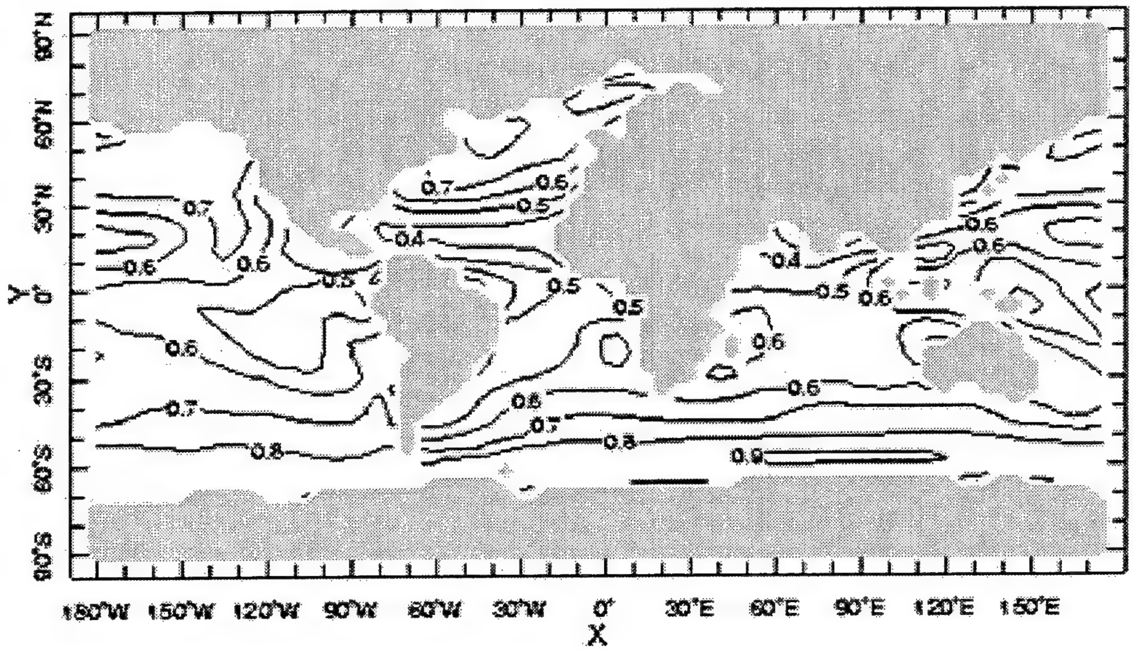

Figure 103. March mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.64748 ± 0.13365 - range: 0.233 to 0.913 - contour interval = 0.1. [Data source: *Berliand and Strokina* (1980) Cloudiness Atlas]

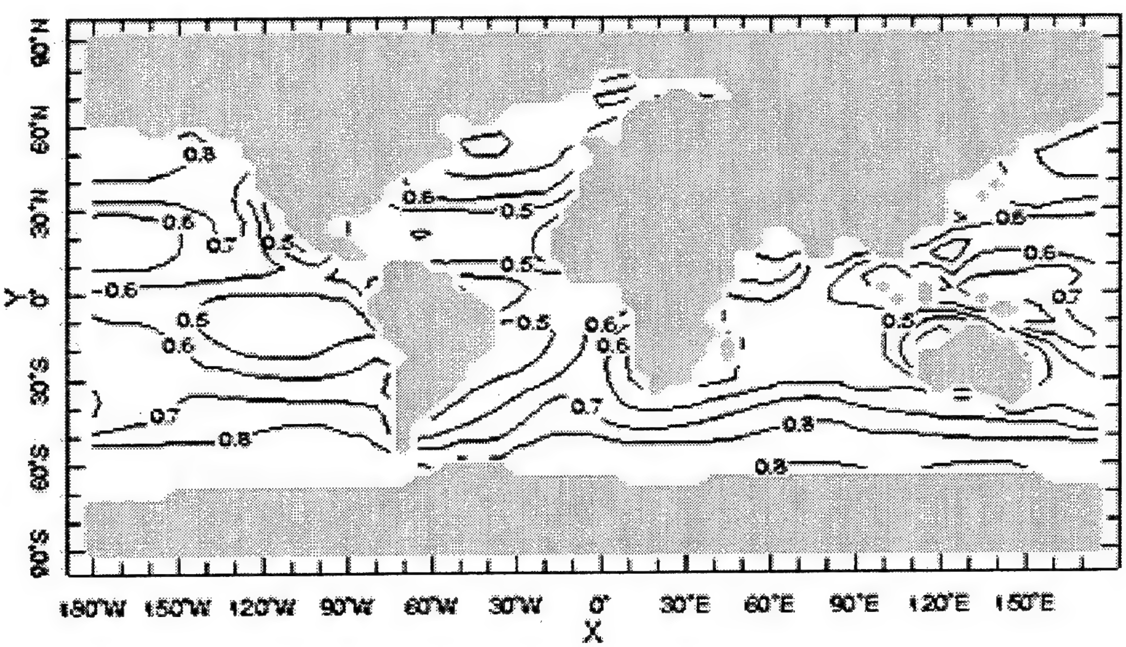

Figure 104. April mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.64759 ± 0.13207 - range: 0.187 to 0.879 - contour interval = 0.1. [Data source: *Berliand and Strokina* (1980) Cloudiness Atlas]

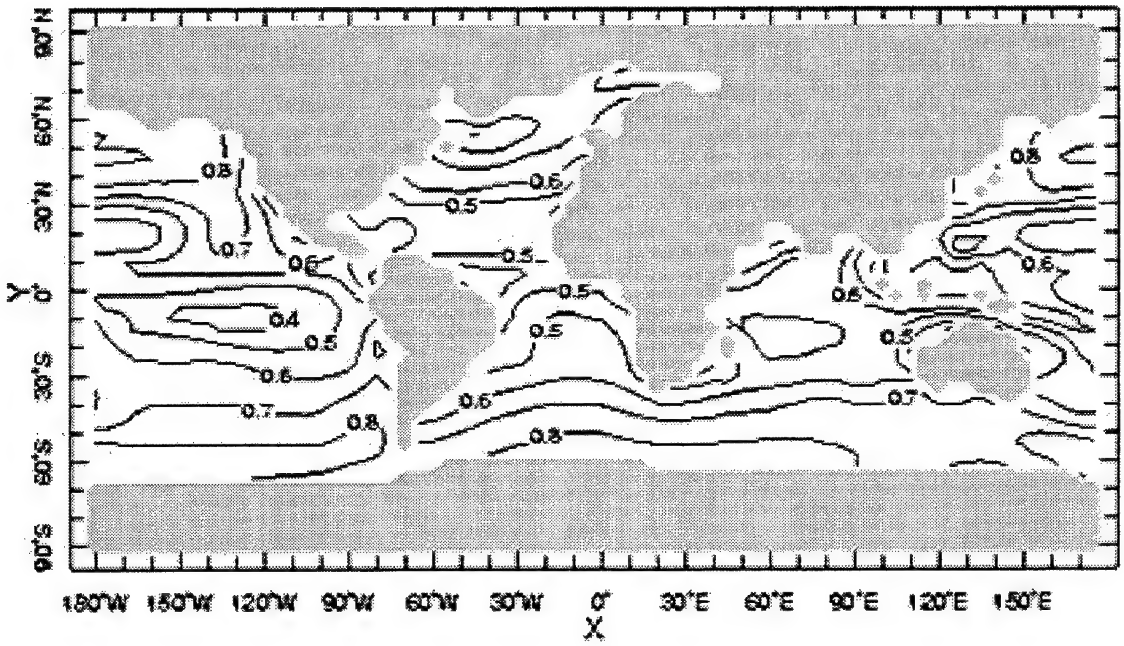

Figure 105. May mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.63567 ± 0.13369- range: 0.194 to 0.916 - contour interval = 0.1. [Data source: *Berliand and Strokina* (1980) Cloudiness Atlas]

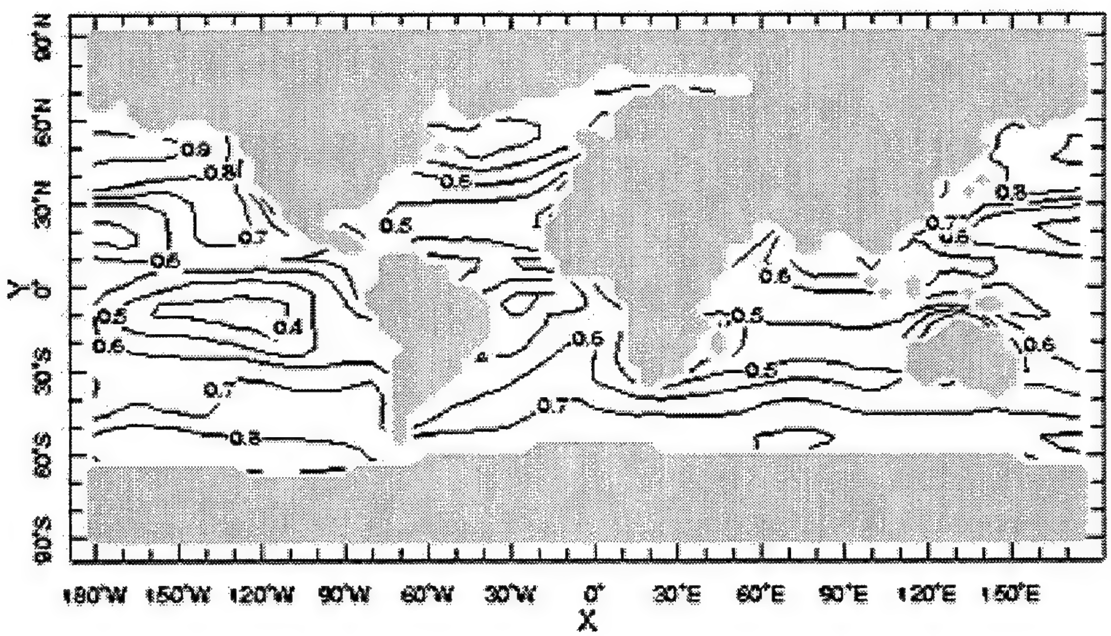

Figure 106. June mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.64605 ± 0.13095 - range: 0.215 to 0.983 - contour interval = 0.1. [Data source: *Berliand and Strokina* (1980) Cloudiness Atlas]

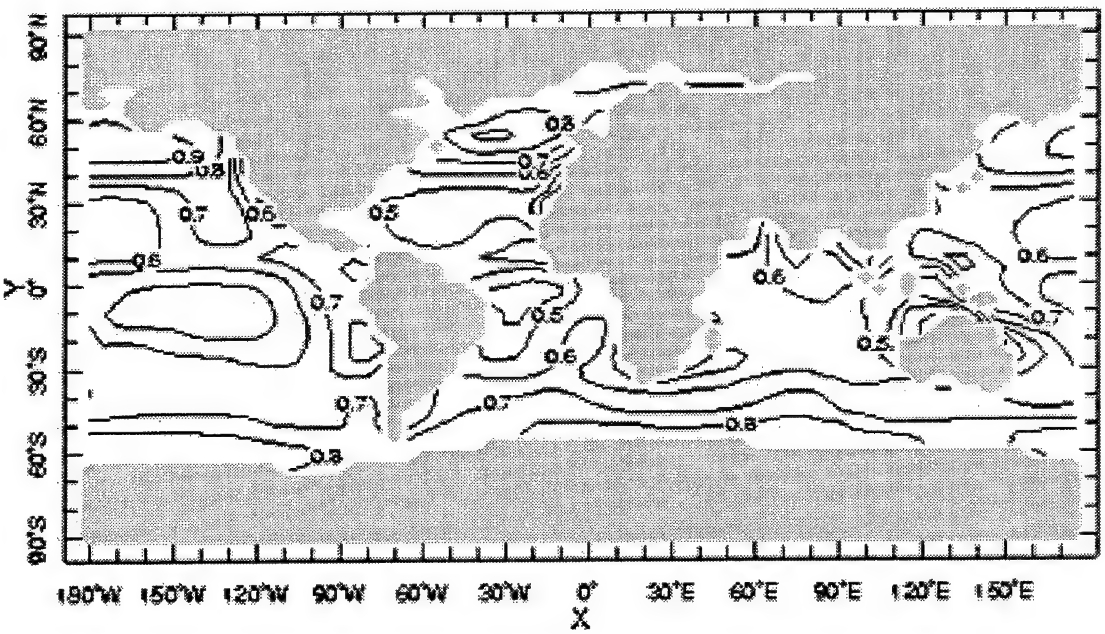

Figure 107. July mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.64913 ± 0.13184 - range: 0.0.115 to 0.947 - contour interval = 0.1. [Data source: *Berliand and Strokina* (1980) Cloudiness Atlas]

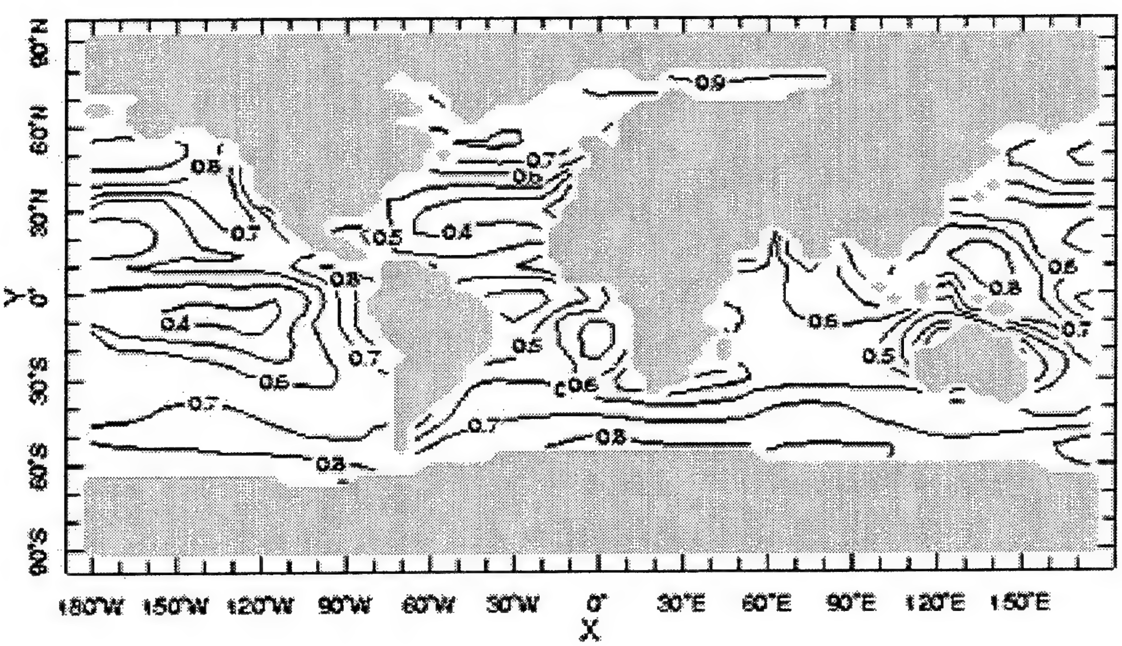

Figure 108. August mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.64136 ± 0.14075 - range: 0.0.120 to 0.943 - contour interval = 0.1. [Data source: *Berliand and Strokina* (1980) Cloudiness Atlas]

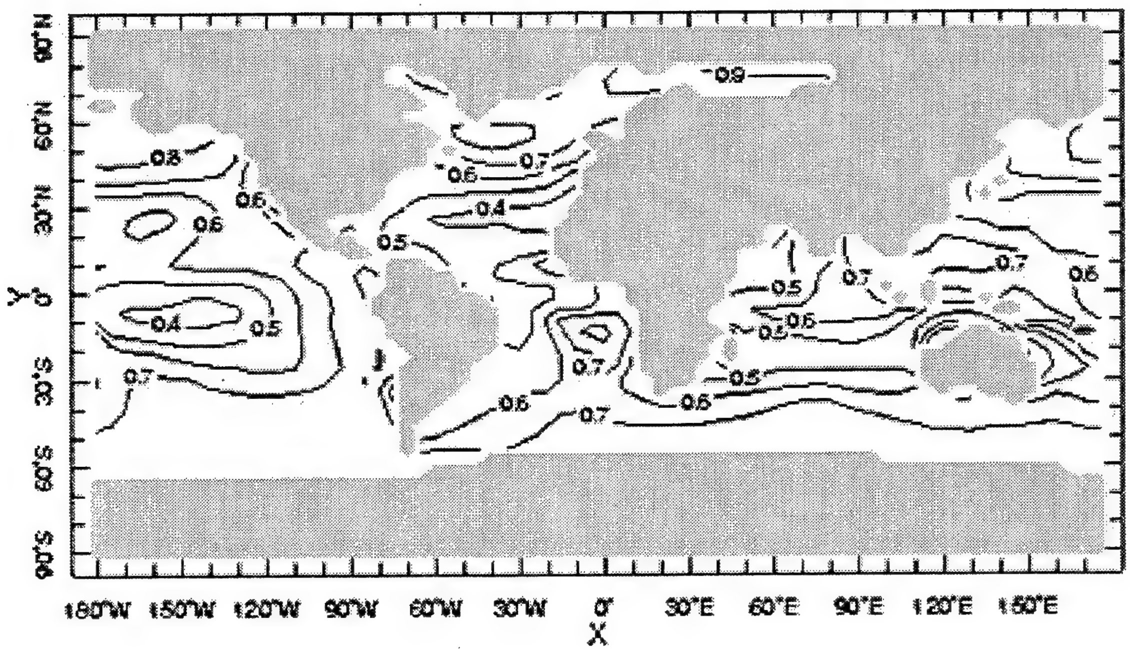

Figure 109. September mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.64253 ± 0.13061 - range: 0.0.108 to 0.920 - contour interval = 0.1. [Data source: *Berliand and Strokina* (1980) Cloudiness Atlas]

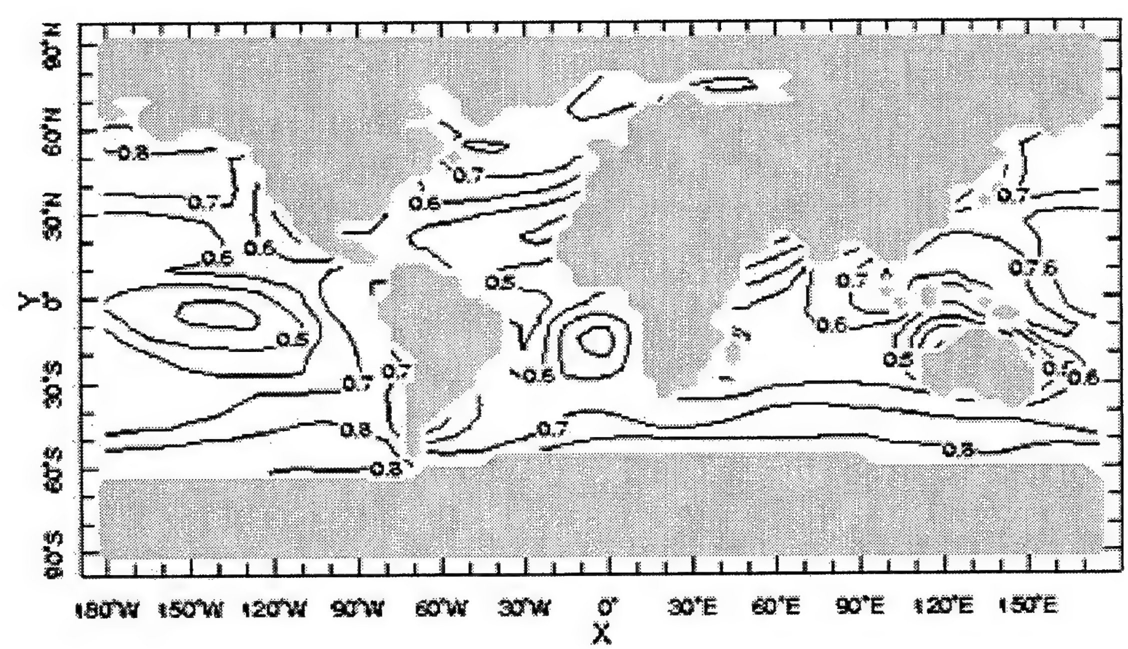

Figure 110. October mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.6502 ± 0.12795 - range: 0.0.122 to 0.914- contour interval = 0.1. [Data source: *Berliand and Strokina* (1980) Cloudiness Atlas]

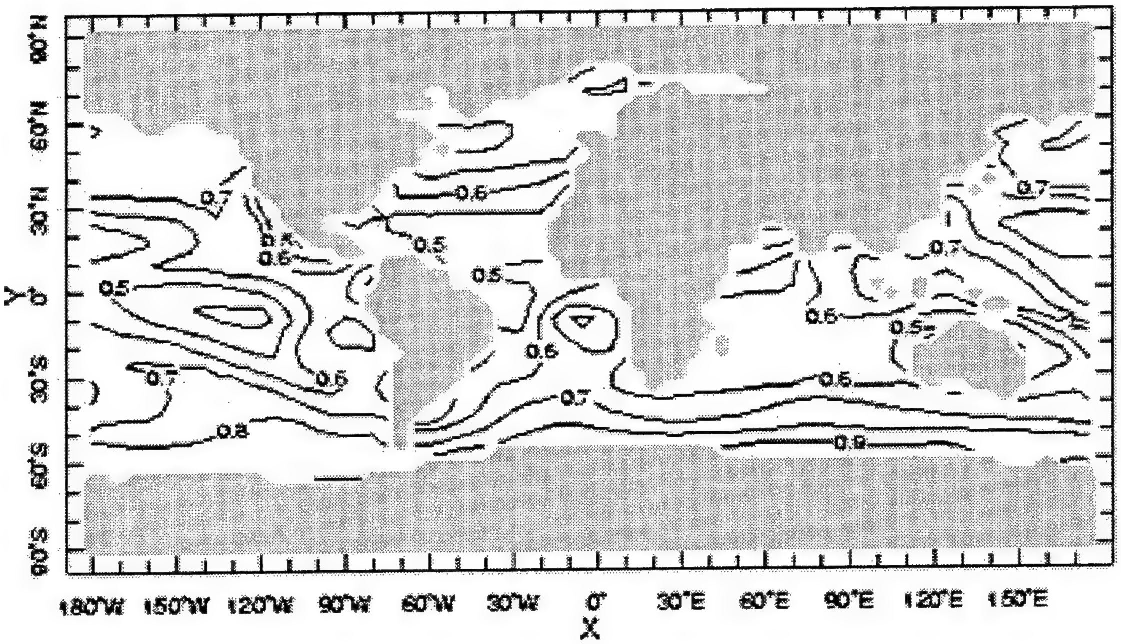

Figure 111. November mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.6495 ± 0.12879 - range: 0.0.181 to 0.918 - contour interval = 0.1. [Data source: *Berliand and Strokina* (1980) Cloudiness Atlas]

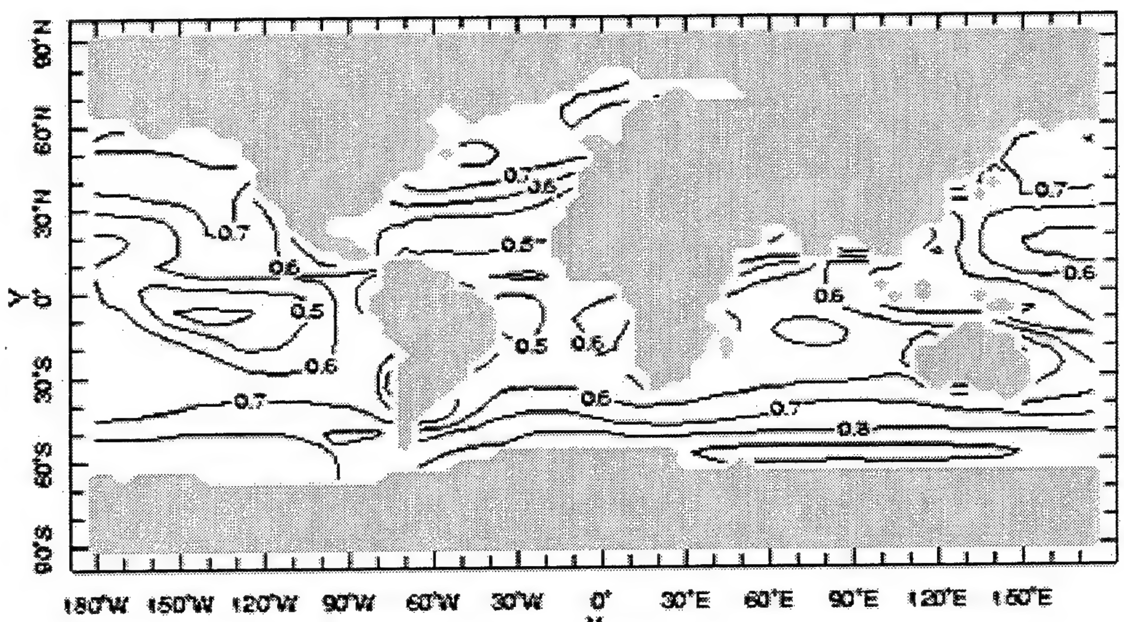

Figure 112. December mean global cloud cover (or cloud fraction) as a function of latitude and longitude: point mean: 0.6542 ± 0.1304 - range: 0.0.19 to 0.92 - contour interval = 0.1. [Data source: *Berliand and Strokina* (1980) Cloudiness Atlas]

4.0 DISCUSSION

The foregoing sections and appendices have presented zonally averaged temperature, wind speed, sound speed, effective sound speed and contours of monthly global mean cloud cover for use by those involved in monitoring compliance with a CTBT (Comprehensive Test Ban Treaty) and, in particular, for those concerned with infrasonic monitoring *per se*.

Clearly, a knowledge of sound and wind speed (or effective sound speed) as a function of altitude is required for modeling and understanding the atmospheric propagation of acoustic energy produced by an atmospheric or underground nuclear explosion: e.g., for providing estimates of yield and height of burst, waveform component phase composition and pressure levels as a function of range. The zonally averaged data, in conjunction with full wave pulse propagation models, should be quite useful in quantifying and improving the seasonal and average performance of infrasonic monitoring networks currently under consideration. Knowledge of those geographical regions characterized by thick and persistent cloud cover can guide the deployment of infrasonic and other sensors to minimize the risk of having a low yield event go undetected by current satellite systems.

The atmospheric environmental parameters which control acoustic propagation (sound and wind speed) are, however, highly variable both as a function of geographical location, time and atmospheric height so that network performance estimates based on zonally or climatologically averaged data may not be fully reliable when compared to actual network performance. There is perhaps a need, therefore, for the acquisition and utilization of real-time or quasi-real-time environmental data for quantifying and improving the performance of infrasonic networks and in understanding the details of long range atmospheric propagation. At least one such satellite system is currently available for the provision of at least some of the required data: the NASA UARS (Upper Atmospheric Research Satellite), and there are likely to be other such systems in the future.

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APPENDIX A: ZONALLY AVERAGED SOUND SPEED (m/s)

The data are based on the COSPAR International Reference Atmosphere: 1986 (0 km to 120 km): Pages 109 through 132.

January Zonally Averaged Sound Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	396.66	396.66	396.2	395.59	394.77	393.9	392.88	391.8
115	357.96	358.35	358.52	357.96	356.43	353.94	350.91	347.97
110	344.07	340.54	335.3	328.99	322.18	315.42	309.17	303.71
105	314.85	310.92	305.63	299.91	294.49	289.8	285.81	282.55
100	275.99	275.41	274.75	274.31	274.31	274.67	275.11	275.26
95	247.6	250.11	253.87	258.58	263.6	268.29	271.87	274.01
90	239.92	243.83	249.71	256.94	264.21	270.39	274.53	276.43
85	244.08	248.01	253.95	261.76	269.72	276.21	279.97	281.34
80	262.99	264.44	266.94	272.32	278.75	284.33	287.15	287.22
75	283.9	283.69	283.69	284.97	287.08	289.73	291.4	291.26
70	301.99	300.92	299.51	297.01	294.42	293.67	294.9	296.19
65	316.25	314.34	311.89	307.99	304.24	302.72	304.64	306.88
60	327.76	325.42	322.81	319.11	315.68	314.15	315.87	318.98
55	336.49	333.91	331.06	327.52	324.3	322.81	323.25	325.67
50	340.89	338.46	335.66	333.07	330.64	328.99	328.19	328.44
45	339.47	337.87	335.84	333.31	331.49	329.48	328.01	326.1
40	333.55	332.28	330.52	328.31	326.16	323.74	321.43	320.43
35	324.74	323.93	322.43	320.24	317.72	315.3	313.57	312.41
30	313.82	313.57	313.31	311.38	308.39	305.7	303.65	302.92
25	308.06	306.88	306.09	303.71	301.32	299.1	297.14	296.4
20	307.41	306.49	304.11	299.57	294.63	290.98	289.04	287.57
15	306.03	305.24	302.58	297.89	292.43	288.06	285.25	283.69
10	302.32	301.38	300.92	301.65	304.24	307.67	309.82	310.27
5	311.44	313.31	316.25	320.99	325.98	329.42	330.94	331.19
0		331	332.94	336.67	341.49	345.24	346.98	347.91

January Zonally Averaged Sound Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
390.72	389.59	388.5	387.46	386.58	385.74	385.11	384.64	384.33
345.65	344.3	343.95	344.19	344.42	344.07	342.9	341.31	339.95
299.57	297.21	296.87	298.77	302.25	306.36	310.01	312.54	313.89
280.05	278.46	278.24	279.76	282.77	286.94	291.4	295.17	297.69
274.97	274.45	274.23	274.75	276.35	278.97	282.12	285.18	287.29
274.67	274.45	274.16	274.6	275.99	278.24	280.98	283.48	285.32
277.01	277.08	277.59	279.18	281.62	284.75	287.78	290.22	291.95
282.05	282.84	284.19	286.73	289.87	293.39	296.19	297.89	299.17
287.71	288.27	289.24	291.88	294.83	298.63	300.65	300.78	301.58
291.6	291.81	292.43	294.69	297.21	300.25	301.92	301.45	302.25
296.53	296.13	295.99	297.35	298.5	301.05	302.85	302.58	303.91
307.73	306.42	304.84	302.92	301.92	301.85	304.11	306.09	308.58
319.17	317.46	313.82	310.08	306.03	304.84	307.67	312.15	315.55
326.47	325.42	322.56	318.54	314.27	312.02	313.63	317.78	320.81
328.44	328.5	327.95	325.73	323.12	319.55	319.55	320.49	320.74
325.98	326.41	327.21	326.35	323.99	320.11	318.79	318.6	317.97
320.62	320.62	320.99	319.86	317.33	315.04	315.11	315.23	315.36
312.54	312.28	312.02	310.4	309.23	307.93	308.13	308.52	308.71
302.52	303.05	303.12	303.38	302.72	301.85	300.85	298.83	297.08
295.99	296.33	296.53	297.21	297.42	296.47	293.46	289.31	285.25
286.87	287.08	288.55	290.84	293.94	295.51	294.63	291.81	287.99
283.34	283.62	285.39	289.52	294.08	296.26	295.65	293.67	291.67
310.4	310.01	307.93	303.45	298.77	296.87	295.72	294.42	293.6
331.25	331.25	329.54	324.74	318.92	313.82	310.34	307.54	305.63
347.97	347.62	345.94	342.78	338.64	334.45	327.58	319.93	316.44

February Zonally Averaged Sound Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	397.21	397.01	396.71	396.3	395.79	395.18	394.52	393.8
115	357.22	357.84	358.29	358.07	356.83	354.73	352.11	349.64
110	338.11	335.54	331.43	326.1	319.99	313.82	308.19	303.58
105	308.71	305.83	301.65	296.94	292.22	288.06	284.68	282.05
100	274.89	274.38	273.94	273.64	273.72	274.16	274.75	275.04
95	251.64	253.63	256.79	260.68	265.05	269.04	272.24	274.09
90	247.36	250.43	255.21	261.06	267.01	271.87	275.04	276.57
85	252.83	255.84	260.52	267.01	273.28	278.03	280.33	281.41
80	268.59	269.49	271.35	276.5	281.91	285.67	286.73	286.87
75	284.82	284.4	284.4	286.45	288.97	290.77	291.26	290.98
70	299.78	298.5	297.55	295.85	294.97	295.1	296.06	296.26
65	313.57	311.05	308.26	304.84	302.58	303.32	305.1	305.37
60	323.43	320.81	318.1	314.72	312.67	312.86	314.98	316.19
55	330.64	328.62	326.59	323.99	321.62	320.99	321.93	324.99
50	335.11	333.49	331.79	330.7	328.93	328.01	328.19	329.78
45	333.97	332.88	331.91	330.7	329.78	328.5	328.74	328.81
40	328.01	327.09	326.1	325.17	324.61	323	322.5	323
35	319.8	319.23	318.47	317.33	315.68	314.66	314.47	313.89
30	310.53	310.34	310.01	308.78	306.88	305.63	304.31	303.65
25	306.22	305.17	303.85	302.19	300.58	298.97	297.35	296.67
20	305.83	304.84	302.85	298.7	294.35	291.05	288.97	287.57
15	304.84	304.18	301.79	297.14	292.29	288.2	285.25	283.76
10	301.79	301.79	301.25	302.05	304.84	307.99	310.08	310.34
5	310.4	311.96	315.68	321.43	326.59	329.66	331	331.19
0		331	333.55	337.15	341.78	345.47	347.33	348.03

February Zonally Averaged Sound Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
393.03	392.32	391.6	390.93	390.31	389.79	389.38	388.65	388.86
347.91	347.22	347.45	348.2	348.78	348.72	347.8	346.4	345.18
300.45	299.04	299.71	302.25	306.09	310.34	313.89	316.25	317.46
280.19	279.25	279.47	281.05	283.97	287.78	291.67	294.9	297.01
274.97	274.53	274.16	274.16	274.97	276.57	278.68	280.76	282.27
274.67	274.38	273.79	273.42	273.5	274.09	275.11	276.21	277.08
277.01	277.01	277.23	277.74	278.82	280.19	281.55	282.55	283.26
281.98	282.62	283.69	284.97	286.8	289.04	290.84	291.6	292.09
287.43	288.2	289.73	290.91	293.19	296.26	298.56	298.56	298.63
291.26	291.95	293.39	294.76	297.01	299.98	302.45	302.12	302.52
296.06	295.72	296.47	297.69	299.37	301.85	304.84	305.24	306.82
305.24	304.38	303.05	302.19	302.45	303.98	307.14	310.66	314.59
316.06	315.04	311.76	309.43	306.55	307.01	311.05	316.89	322.43
326.04	325.42	322.5	319.42	315.23	313.7	316.44	321.81	326.96
330.64	330.64	329.48	326.78	323.81	320.43	319.42	320.3	322.31
329.6	329.91	329.78	327.82	325.05	320.87	317.46	315.3	314.47
323.56	323.68	323.37	321.56	318.73	314.47	312.22	310.4	308.78
314.08	314.08	314.15	312.41	309.62	305.96	305.63	306.03	305.24
303.18	303.58	303.71	303.58	301.12	298.97	299.17	300.38	299.64
296.26	296.26	296.19	296.53	296.6	296.4	295.1	293.32	291.12
286.73	287.08	288.76	291.05	294.15	296.06	295.72	293.46	290.22
283.69	283.9	285.6	289.66	294.42	296.87	296.26	294.01	291.12
310.34	310.21	308.32	303.65	298.77	297.01	295.99	294.69	293.39
331.19	331.31	329.42	324.68	318.73	313.7	310.47	308.06	306.36
347.97	347.51	345.71	342.49	338.4	334.39	327.64	319.86	315.68

March Zonally Averaged Sound Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	394.98	394.93	394.82	394.72	394.62	394.47	394.31	394.11
115	353.37	354.28	355.13	355.41	354.73	353.2	351.25	349.64
110	328.62	327.02	324.18	319.93	314.85	309.69	305.3	302.19
105	301.38	299.31	296.19	292.36	288.48	285.11	282.62	281.05
100	275.19	274.6	274.01	273.5	273.35	273.72	274.31	274.82
95	259.59	260.68	262.45	264.97	267.77	270.54	272.76	274.16
90	260.52	262.3	264.97	268.22	271.5	274.09	275.84	276.79
85	269.19	270.76	273.06	275.92	278.68	280.41	281.34	282.05
80	283.41	283.69	283.83	285.11	286.66	287.22	287.15	287.92
75	292.84	292.29	291.67	291.26	291.53	291.88	291.67	291.74
70	299.91	298.9	298.29	295.92	295.38	296.67	297.08	296.13
65	308.84	306.55	304.58	302.05	302.12	304.58	305.5	304.77
60	315.49	313.37	311.89	310.47	310.21	311.63	313.76	314.08
55	321.31	319.99	319.17	319.55	319.99	320.43	321.12	323.99
50	325.85	325.98	326.41	327.52	328.13	328.13	328.44	329.91
45	323.43	324.24	325.73	327.15	327.52	327.39	328.74	330.09
40	316	316.57	318.22	320.56	321.43	321.37	322.81	324.18
35	307.67	308.78	310.53	311.89	312.28	313.12	313.76	314.47
30	301.52	302.45	303.25	303.78	304.24	304.51	304.71	304.38
25	298.77	298.83	299.91	299.84	299.44	298.77	298.16	297.89
20	300.51	300.25	299.24	297.48	294.49	291.46	289.04	287.78
15	301.32	301.38	299.98	296.67	292.57	288.34	285.25	283.55
10	300.51	300.31	299.91	300.92	303.71	307.21	309.69	310.4
5	308.26	310.79	315.3	320.93	325.79	329.05	330.88	331.19
0		330.88	332.82	336.61	341.6	345.3	347.27	348.2

March Zonally Averaged Sound Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
393.96	393.8	393.6	393.44	393.29	393.19	393.09	393.03	392.98
348.78	349.07	350.16	351.65	352.86	353.25	352.74	351.65	350.56
300.78	301.12	303.25	306.95	311.51	316.13	319.93	322.43	323.74
280.26	280.33	281.34	283.41	286.45	290.08	293.74	296.74	298.63
274.97	274.67	274.16	273.72	273.64	274.16	275.11	276.14	276.94
274.67	274.23	273.2	271.58	269.87	268.22	266.94	266.11	265.65
277.15	276.94	276.5	275.7	274.38	272.98	271.5	270.16	269.19
282.55	282.55	282.7	282.77	282.12	281.7	280.98	279.61	278.39
288.69	288.69	289.45	290.56	290.22	291.33	292.22	291.05	289.73
291.95	291.95	293.6	295.72	296.19	298.16	299.04	297.28	295.58
295.79	295.51	297.55	299.57	300.45	302.32	302.52	300.78	299.1
304.24	303.78	303.71	304.31	304.31	305.7	305.04	304.31	303.45
314.4	313.25	311.25	310.4	309.56	309.88	309.75	310.86	311.44
324.8	324.12	321.87	319.99	318.66	317.65	317.4	319.61	321.43
330.7	330.21	329.05	327.27	326.53	325.11	324.3	324.36	324.8
330.76	330.58	329.78	328.25	327.33	325.79	323.74	321.5	320.11
324.8	324.61	323.68	321.87	320.93	318.85	316	312.92	311.05
314.91	315.04	314.4	312.92	311.31	308.58	306.36	305.57	305.7
304.18	304.24	304.44	303.91	301.38	298.97	298.36	299.31	300.65
297.21	296.94	296.94	296.94	296.6	296.4	296.47	296.87	297.48
287.57	287.64	288.97	291.4	294.42	296.47	296.87	295.79	294.01
283.34	283.76	285.81	289.87	294.42	296.94	297.28	296.06	294.01
310.47	310.21	308.13	303.52	299.1	297.42	296.94	296.06	294.83
331.25	331.25	329.66	325.23	319.99	315.3	311.83	309.1	307.01
348.14	347.68	345.88	342.6	338.7	335.24	328.87	321.37	316.19

April Zonally Averaged Sound Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	390.1	390.21	390.41	390.62	390.93	391.29	391.7	392.11
115	346.98	348.14	349.41	350.16	349.99	349.07	347.97	347.27
110	319.74	318.6	316.25	312.73	308.52	304.31	301.25	299.84
105	297.08	295.17	292.15	288.55	284.97	282.12	280.33	279.76
100	278.89	277.81	276.35	274.97	274.09	273.79	274.09	274.6
95	270.61	270.54	270.46	270.83	271.5	272.46	273.42	274.31
90	276.14	276.06	276.06	276.14	276.28	276.43	276.65	277.08
85	286.87	286.31	285.39	284.68	283.9	283.05	282.55	282.91
80	299.51	297.82	294.9	292.64	290.77	289.04	288.13	289.38
75	304.44	302.65	300.11	296.67	294.42	292.77	291.26	291.4
70	306.29	304.91	303.38	299.37	297.48	296.67	294.9	293.12
65	311.83	309.56	307.01	303.38	303.25	304.64	303.45	301.79
60	317.27	314.47	311.57	309.95	310.4	311.12	312.22	312.6
55	320.3	317.91	315.62	316.51	318.73	320.18	321.75	323.12
50	322.93	321.87	320.81	322.18	325.73	327.27	328.01	329.29
45	319.11	318.79	318.73	321.18	324.18	325.98	327.95	329.48
40	308.97	308.45	309.56	313.37	316.44	318.79	321.75	323.87
35	297.69	297.35	300.11	304.11	307.86	310.53	312.86	315.11
30	291.05	292.15	294.28	298.09	301.12	303.32	304.77	305.37
25	286.38	290.15	295.17	297.48	298.5	298.77	298.7	298.43
20	292.29	294.01	295.58	295.92	294.22	291.74	289.45	288.34
15	295.72	297.08	297.55	296.06	292.98	289.04	285.6	283.48
10	296.53	297.48	298.09	299.04	301.72	305.43	308.97	310.47
5	306.82	309.49	313.57	318.92	324.05	327.89	330.52	331.25
0		330.09	332.52	336.31	341.13	344.71	346.93	348.2

April Zonally Averaged Sound Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
392.52	392.98	393.39	393.8	394.16	394.47	394.72	394.87	394.98
347.45	348.72	350.74	352.97	354.73	355.64	355.58	354.85	354.11
300.25	302.45	306.16	311.05	316.57	321.93	326.53	329.78	331.67
280.19	281.41	283.41	286.24	289.8	293.87	297.96	301.38	303.65
274.97	274.89	274.45	273.79	273.35	273.2	273.5	274.01	274.38
274.67	274.16	272.54	269.87	266.41	262.83	259.67	257.18	255.61
277.23	276.79	275.55	273.2	269.49	265.12	260.83	257.18	254.74
282.84	282.2	281.41	279.76	276.72	272.91	269.27	265.58	263.14
289.45	288.48	288.41	287.99	286.02	284.26	283.48	281.7	280.48
291.05	290.77	292.5	293.94	293.87	294.35	294.9	294.01	293.39
292.64	293.53	297.21	299.17	300.31	301.72	302.45	302.32	301.99
301.65	302.32	304.11	305.63	306.82	307.6	307.73	307.01	306.22
312.92	312.28	310.99	311.7	312.92	313.76	313.95	314.08	313.76
323.43	322.5	320.62	320.74	322.06	322.62	322.25	322.87	323.12
329.6	329.29	328.68	328.68	329.54	329.48	329.36	329.23	328.99
329.91	329.6	329.17	329.29	330.03	330.33	328.99	327.02	325.6
324.61	324.3	323.31	323	324.18	323.62	321.25	318.6	316.83
315.94	315.74	314.79	314.21	314.27	313.18	310.86	307.99	306.55
305.04	304.64	305.43	304.84	303.32	302.12	301.58	301.18	301.12
297.89	297.75	298.09	297.96	297.28	297.55	298.7	300.58	302.39
288.06	288.34	289.8	291.95	294.35	296.74	298.43	299.64	300.45
283.19	283.69	285.95	289.87	294.01	296.87	298.63	299.64	300.04
310.73	310.21	307.99	303.98	300.04	298.5	298.43	298.7	298.63
331.31	331.25	329.91	326.65	322.12	317.84	314.27	311.51	309.56
348.26	347.91	346.35	343.31	339.41	336.02	331.67	324.99	319.36

May Zonally Averaged Sound Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	367.7	368.2	369	370	371.3	372.8	374.4	376.1
115	288.3	290.6	293.1	295	295.4	294.8	294	294
110	245.4	243.5	239.9	234.6	228.5	223.2	220	219.8
105	218.6	215.3	210.3	204.4	198.9	194.9	192.8	192.9
100	201.1	198.6	195	191.4	188.6	187	186.6	187.1
95	196.4	194.5	192	189.4	187.4	186.4	186.4	186.9
90	206.1	204	201.1	198	194.8	192.2	190.7	190.4
85	219.6	217.1	213.7	210.2	205.9	201.6	198.8	198
80	231	227.2	223.2	219.4	213.9	208	204.6	205
75	234.1	231.6	230	225.1	218.6	211.9	207.1	205.7
70	235	235.2	236.6	230.8	223.7	216.9	210.6	206.9
65	240.6	241.9	243.7	237.3	231	228.9	225.4	222.3
60	249.8	250.5	249.3	243.5	238.5	240.1	241.6	243
55	257.6	257	253.2	249.2	248.1	252	256.1	258.5
50	260.4	259.5	254.8	252.3	255.7	261.3	264.8	266.7
45	253.6	251.5	246.8	247.1	255.2	261	265.3	265.8
40	236.7	234.8	231.8	233.7	241.5	249.8	255.5	258
35	220.6	217.6	215	218.5	228.5	236.2	242.4	246.1
30	204.2	202.9	204.7	212.6	220.9	226.9	229.8	231.7
25	187.5	196.5	206.6	214.6	219.2	221.1	221.5	221.3
20	198.5	204.3	210.4	215	215.1	212.3	209.2	207.4
15	206.5	210.2	214.3	216.2	214	208.6	203	199.9
10	211.7	214.3	216.8	219.5	223.3	229.4	235.6	238.8
5	231.8	236.6	243.4	250.7	258.1	264.6	270	272.3
0		273.4	276.7	280.7	287.5	293.4	297.8	300.5

May Zonally Averaged Sound Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
378	379.8	381.5	383.2	384.6	385.9	387	387.7	388.2
295.8	299.3	303.9	308.8	312.8	315.1	315.7	315.1	314.2
222.6	227.9	235.3	244.3	254.2	264.2	273.3	280.7	285.5
194.6	197.6	201.6	206.7	212.8	219.9	227.4	234.3	239.2
187.7	187.9	187.5	186.8	186.1	185.9	186.2	186.8	187.4
187.3	186.4	183.7	179.1	173.3	167.2	161.6	157.1	154.3
190.5	189.8	187.2	182.3	174.9	166.5	158.4	151.8	147.4
197.5	196.4	194.2	189.8	182.4	173.9	165.8	158.9	154.3
205.2	204.3	202.6	199.8	193.6	188.2	184.6	180.9	178.6
206.1	207.2	208.4	208.1	205.6	204.9	205.6	204.8	204.2
207.4	211	215.5	217.5	217.7	220	223.1	224.9	225.7
223.4	225.9	228.7	229.9	231	233.9	236.7	238.6	239.9
243.5	243.2	242.1	242.8	243.6	247.8	250.9	254.7	257.8
258.7	256.8	255.2	256.6	259.7	262.8	265.5	268.9	272.4
266.7	266.5	267.9	269.2	271.2	273.4	275.3	277.9	280.6
266	266.4	267.3	269.7	272.9	274.6	275.6	276.1	276.9
258.7	258.6	258	259.4	262.9	263.9	263.9	264.9	264.7
247.3	246.7	245.4	245.7	247	247.6	248	248	247.2
231.4	230.8	231.9	231.9	230.8	230.8	232	233.8	234.8
220.6	220.8	222	221.8	221.3	222.5	224.2	226.6	229
206.8	207.3	209.4	212.5	216.2	220.2	224.1	227.5	230
199.7	200.2	203	208.2	214.2	219.4	223.4	226.4	228.7
239.5	239.4	237	232.1	226.3	223.7	223.7	224.8	226.2
272.5	272.5	271.3	267.5	261.9	255.5	250.3	246	242.8
301	300.9	298.7	294.2	287.9	281.6	277.3	269.2	263.6

June Zonally Averaged Sound Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	396.66	396.66	396.2	395.59	394.77	393.9	392.88	391.8
115	357.96	358.35	358.52	357.96	356.43	353.94	350.91	347.97
110	344.07	340.54	335.3	328.99	322.18	315.42	309.17	303.71
105	314.85	310.92	305.63	299.91	294.49	289.8	285.81	282.55
100	275.99	275.41	274.75	274.31	274.31	274.67	275.11	275.26
95	247.6	250.11	253.87	258.58	263.6	268.29	271.87	274.01
90	239.92	243.83	249.71	256.94	264.21	270.39	274.53	276.43
85	244.08	248.01	253.95	261.76	269.72	276.21	279.97	281.34
80	262.99	264.44	266.94	272.32	278.75	284.33	287.15	287.22
75	283.9	283.69	283.69	284.97	287.08	289.73	291.4	291.26
70	301.99	300.92	299.51	297.01	294.42	293.67	294.9	296.19
65	316.25	314.34	311.89	307.99	304.24	302.72	304.64	306.88
60	327.76	325.42	322.81	319.11	315.68	314.15	315.87	318.98
55	336.49	333.91	331.06	327.52	324.3	322.81	323.25	325.67
50	340.89	338.46	335.66	333.07	330.64	328.99	328.19	328.44
45	339.47	337.87	335.84	333.31	331.49	329.48	328.01	326.1
40	333.55	332.28	330.52	328.31	326.16	323.74	321.43	320.43
35	324.74	323.93	322.43	320.24	317.72	315.3	313.57	312.41
30	313.82	313.57	313.31	311.38	308.39	305.7	303.65	302.92
25	308.06	306.88	306.09	303.71	301.32	299.1	297.14	296.4
20	307.41	306.49	304.11	299.57	294.63	290.98	289.04	287.57
15	306.03	305.24	302.58	297.89	292.43	288.06	285.25	283.69
10	302.32	301.38	300.92	301.65	304.24	307.67	309.82	310.27
5	311.44	313.31	316.25	320.99	325.98	329.42	330.94	331.19
0		331	332.94	336.67	341.49	345.24	346.98	347.91

June Zonally Averaged Sound Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
390.72	389.59	388.5	387.46	386.58	385.74	385.11	384.64	384.33
345.65	344.3	343.95	344.19	344.42	344.07	342.9	341.31	339.95
299.57	297.21	296.87	298.77	302.25	306.36	310.01	312.54	313.89
280.05	278.46	278.24	279.76	282.77	286.94	291.4	295.17	297.69
274.97	274.45	274.23	274.75	276.35	278.97	282.12	285.18	287.29
274.67	274.45	274.16	274.6	275.99	278.24	280.98	283.48	285.32
277.01	277.08	277.59	279.18	281.62	284.75	287.78	290.22	291.95
282.05	282.84	284.19	286.73	289.87	293.39	296.19	297.89	299.17
287.71	288.27	289.24	291.88	294.83	298.63	300.65	300.78	301.58
291.6	291.81	292.43	294.69	297.21	300.25	301.92	301.45	302.25
296.53	296.13	295.99	297.35	298.5	301.05	302.85	302.58	303.91
307.73	306.42	304.84	302.92	301.92	301.85	304.11	306.09	308.58
319.17	317.46	313.82	310.08	306.03	304.84	307.67	312.15	315.55
326.47	325.42	322.56	318.54	314.27	312.02	313.63	317.78	320.81
328.44	328.5	327.95	325.73	323.12	319.55	319.55	320.49	320.74
325.98	326.41	327.21	326.35	323.99	320.11	318.79	318.6	317.97
320.62	320.62	320.99	319.86	317.33	315.04	315.11	315.23	315.36
312.54	312.28	312.02	310.4	309.23	307.93	308.13	308.52	308.71
302.52	303.05	303.12	303.38	302.72	301.85	300.85	298.83	297.08
295.99	296.33	296.53	297.21	297.42	296.47	293.46	289.31	285.25
286.87	287.08	288.55	290.84	293.94	295.51	294.63	291.81	287.99
283.34	283.62	285.39	289.52	294.08	296.26	295.65	293.67	291.67
310.4	310.01	307.93	303.45	298.77	296.87	295.72	294.42	293.6
331.25	331.25	329.54	324.74	318.92	313.82	310.34	307.54	305.63
347.97	347.62	345.94	342.78	338.64	334.45	327.58	319.93	316.44

July Zonally Averaged Sound Speed (m/s)

Height (km)	70S	60S	50S	40S	30S	20S	10S	EQ
120	384.33	384.8	385.48	386.31	387.25	388.29	389.38	390.51
115	341.07	342.6	343.78	344.13	343.95	343.72	344.07	345.41
110	312.34	309.82	306.16	302.05	298.56	296.74	297.08	299.51
105	295.24	291.4	286.94	282.77	279.69	278.17	278.46	280.05
100	285.39	282.34	279.11	276.43	274.82	274.23	274.45	274.97
95	283.83	281.27	278.46	276.14	274.67	274.16	274.45	274.67
90	290.29	287.71	284.61	281.48	278.89	277.3	276.79	276.72
85	297.08	295.1	292.36	288.83	285.46	282.98	281.7	281.05
80	298.09	297.21	295.45	291.67	288.27	285.88	285.11	285.04
75	299.98	299.98	298.23	294.15	290.43	288.06	287.43	287.57
70	304.91	305.3	302.65	297.48	293.74	291.33	290.91	291.26
65	312.47	311.63	307.86	303.25	300.45	300.51	300.85	301.58
60	321.18	318.16	313.18	308.71	308.84	310.47	312.67	313.63
55	328.01	323.56	318.73	315.74	318.03	320.62	322.31	322.68
50	329.17	326.1	322.43	322.68	324.92	326.78	326.78	326.35
45	324.24	322.43	320.18	321.75	324.12	325.42	324.86	324.24
40	316.76	314.85	311.51	312.09	316.06	318.29	318.85	318.92
35	306.49	302.72	299.24	302.19	306.75	310.08	311.44	311.89
30	289.66	288.41	291.12	297.89	302.39	303.38	303.78	303.38
25	274.38	281.98	291.67	297.14	298.36	298.5	297.69	297.28
20	279.54	285.81	291.74	294.35	293.32	291.46	290.36	289.87
15	282.27	288.34	293.74	294.63	290.91	286.87	285.32	285.32
10	287.71	291.4	295.38	299.24	303.78	307.93	309.49	309.69
5	306.36	311.18	315.87	320.3	325.05	329.29	330.94	330.88
0	328.19	332.16	335.48	339.53	342.54	345.24	347.22	347.68

July Zonally Averaged Sound Speed (m/s)

10N	20N	30N	40N	50N	60N	70N	80N
391.65	392.73	393.75	394.67	395.49	396.1	396.6	396.86
347.74	350.74	353.77	356.26	357.79	358.35	358.18	357.79
303.65	309.1	315.42	322.18	328.99	335.36	340.6	344.19
282.55	285.88	289.87	294.56	299.98	305.76	311.12	315.04
275.26	275.11	274.67	274.38	274.38	274.75	275.48	276.06
274.01	271.87	268.22	263.52	258.51	253.79	249.95	247.44
276.21	274.31	270.09	263.9	256.39	249.14	243.25	239.41
280.55	279.11	275.33	268.74	260.37	252.44	246.54	243
285.11	284.75	282.05	276.28	268.97	263.45	261.37	260.99
287.99	288.27	287.01	284.12	281.05	279.69	280.55	281.84
291.67	291.4	291.05	291.46	293.53	296.13	298.56	300.38
301.38	300.58	299.78	300.98	304.77	309.17	312.8	314.98
313.82	312.22	311.44	312.54	316.25	320.37	324.05	326.47
321.87	320.49	320.37	321.68	324.99	328.68	331.98	334.75
326.16	326.04	326.53	328.07	330.45	333.07	336.08	338.52
324.12	325.54	326.41	328.38	330.33	333	335.11	336.49
318.29	318.29	319.99	322.12	324.55	327.09	328.99	329.72
311.25	311.44	312.22	313.82	316.32	318.41	319.99	320.43
303.58	303.78	304.77	306.09	308.13	309.43	310.92	311.7
297.69	298.23	299.1	300.18	301.58	303.25	304.91	306.55
290.15	291.19	292.64	295.17	298.77	301.92	304.24	305.89
285.6	286.8	289.11	292.84	297.55	300.78	303.12	304.97
310.01	310.27	310.01	307.54	304.38	302.98	302.98	303.58
330.94	331.06	330.88	328.93	325.85	323.43	321.43	319.61
348.09	347.56	346.46	343.6	339.06	337.99	335.6	332.34

August Zonally Averaged Sound Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	388.45	388.65	388.96	389.43	390	390.62	391.34	392.11
115	344.66	345.88	347.33	348.26	348.37	347.8	347.1	346.93
110	317.02	315.81	313.44	309.88	305.7	301.85	299.44	298.9
105	297.01	294.9	291.6	287.64	283.83	280.91	279.33	279.18
100	282.77	281.19	279.04	276.79	275.11	274.23	274.16	274.53
95	277.95	276.94	275.7	274.53	273.79	273.57	273.87	274.38
90	283.97	283.12	281.98	280.48	278.97	277.74	277.08	276.86
85	291.95	291.33	290.5	288.69	286.52	284.54	282.98	281.84
80	296.4	296.19	296.26	294.35	291.67	289.45	287.64	285.88
75	299.1	298.77	299.44	297.89	295.24	292.84	290.98	289.18
70	302.65	301.65	302.12	300.65	298.09	295.85	294.28	293.19
65	310.6	307.86	305.5	303.85	301.45	300.18	300.98	301.99
60	320.74	316.83	311.63	307.86	305.57	307.34	309.75	312.54
55	330.21	326.16	320.05	314.72	313.63	317.4	320.56	323
50	332.94	330.09	325.73	321.06	321.31	324.43	327.39	328.19
45	329.23	328.25	325.54	321.62	321.75	324.3	326.84	327.09
40	322.93	323.43	320.99	315.94	314.59	316.7	319.42	320.49
35	314.08	314.59	311.44	306.68	306.36	308.52	310.92	311.76
30	297.35	298.36	296.94	297.69	300.92	303.12	303.25	303.45
25	271.65	278.68	286.87	294.56	298.36	298.83	298.16	297.14
20	274.89	279.9	286.87	293.19	295.65	294.01	291.74	290.77
15	277.66	281.48	287.92	293.87	294.9	291.19	286.94	285.25
10	284.54	287.29	291.26	295.79	299.71	303.91	307.86	309.43
5	303.91	307.27	311.57	316	320.18	324.92	329.42	330.88
0		329.78	331.61	334.75	339	342.37	345.18	347.04

August Zonally Averaged Sound Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
392.88	393.65	394.42	395.13	395.74	396.3	396.76	397.06	397.26
347.68	349.47	352	354.68	356.83	358.07	358.35	357.9	357.34
300.31	303.58	308.26	314.02	320.24	326.41	331.85	336.08	338.7
280.19	282.12	284.82	288.27	292.5	297.21	302.12	306.36	309.3
274.97	275.11	274.75	274.23	273.79	273.72	274.01	274.45	274.89
274.67	274.09	272.17	268.97	264.82	260.45	256.39	253.23	251.16
276.86	276.5	274.97	271.72	266.64	260.52	254.5	249.63	246.54
281.48	281.27	280.33	277.81	272.76	266.18	259.52	254.58	252.04
285.95	286.52	286.73	285.46	281.05	275.26	270.09	267.92	268.37
289.45	290.43	291.26	290.77	288.27	285.25	283.34	283.41	285.25
294.15	295.31	295.72	295.24	294.69	294.97	296.87	298.43	300.58
303.18	303.85	304.05	303.05	302.19	303.71	307.67	311.31	314.02
313.63	313.95	313.37	311.83	311.38	312.99	316.64	320.37	322.87
323.37	322.43	319.93	318.98	319.3	321.43	324.18	326.78	328.99
328.01	327.33	325.98	325.54	325.98	328.01	329.29	331.25	333.13
326.72	325.91	325.85	325.42	326.65	327.89	329.48	330.76	331.61
320.43	319.55	318.54	318.92	320.81	321.87	323.31	324.61	324.99
311.83	311.31	311.18	311.05	312.15	314.21	315.62	316.44	316.51
302.98	303.25	303.38	304.11	304.91	306.68	307.47	308.19	308.58
296.47	296.81	297.35	298.43	299.51	300.72	301.92	302.98	303.98
290.43	290.36	291.12	292.64	295.04	298.36	301.05	302.85	304.24
285.25	285.53	286.73	288.9	292.5	297.14	300.31	302.32	303.91
309.56	309.95	310.34	310.01	307.54	304.11	302.39	301.99	302.45
330.76	330.94	331.25	330.94	329.05	325.6	322.68	320.37	318.29
347.56	348.14	347.74	346.98	344.6	340.01	338.11	335.42	331.85

September Zonally Averaged Sound Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	392.68	392.78	392.83	392.98	393.14	393.34	393.55	393.75
115	350.05	351.14	352.28	352.8	352.51	351.37	349.93	348.89
110	323.06	321.75	319.3	315.55	311.05	306.55	302.98	300.92
105	298.36	296.47	293.46	289.8	286.16	283.19	281.19	280.26
100	277.3	276.43	275.33	274.31	273.72	273.72	274.16	274.67
95	266.64	266.94	267.62	268.67	270.16	271.8	273.2	274.31
90	270.46	271.21	272.39	273.57	274.75	275.7	276.43	276.79
85	279.69	280.55	281.7	282.12	282.41	282.34	282.2	281.98
80	290.7	291.4	292.36	291.12	290.08	288.97	287.92	287.01
75	297.08	297.62	299.1	297.96	295.99	293.67	291.67	289.87
70	301.99	301.85	303.12	302.39	300.45	297.75	295.72	293.53
65	308.58	306.62	306.09	305.63	304.11	302.78	302.12	302.05
60	318.98	314.66	310.79	309.04	308.45	309.17	309.95	311.83
55	330.27	324.36	317.91	315.36	316.19	318.85	320.81	322.62
50	334.63	329.42	324.05	321.56	323	325.6	327.76	328.62
45	334.15	330.33	325.79	322.56	323.06	325.6	328.01	328.68
40	331.91	328.74	322.75	316.95	316.06	318.35	321.5	322.62
35	325.3	321.93	314.85	308.71	307.86	310.14	312.8	313.82
30	309.23	307.67	303.71	301.12	301.52	303.25	304.05	304.18
25	285.53	289.52	293.67	298.23	299.64	298.9	297.82	297.14
20	281.41	284.19	289.66	295.45	296.53	294.01	291.4	290.15
15	279.4	282.91	288.9	294.83	295.45	291.26	286.94	285.04
10	284.97	287.5	291.74	296.47	300.18	304.24	307.99	309.69
5	304.05	307.14	311.7	316.25	320.87	325.73	329.54	330.94
0		330.58	332.28	335.11	339	342.37	345.24	347.1

September Zonally Averaged Sound Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
393.96	394.21	394.42	394.62	394.82	394.98	395.08	395.18	395.23
348.78	349.7	351.43	353.43	355.02	355.75	355.53	354.73	353.82
300.72	302.32	305.57	310.14	315.36	320.56	324.86	327.82	329.48
280.26	281.12	282.84	285.39	288.83	292.71	296.6	299.84	301.92
274.97	274.82	274.31	273.72	273.35	273.42	273.87	274.53	275.04
274.67	274.16	272.76	270.39	267.47	264.51	261.91	259.98	258.74
277.01	276.72	275.77	273.94	271.06	267.54	263.98	261.14	259.21
281.98	281.91	281.34	280.41	278.24	275.04	271.72	269.34	267.32
287.15	287.43	287.36	287.57	286.31	283.97	282.2	282.12	280.98
290.08	290.91	291.67	292.29	291.46	290.36	290.22	290.98	290.77
293.87	295.04	296.53	296.74	295.65	295.51	297.28	298.09	298.7
302.32	303.38	304.44	304.24	302.32	301.85	304.11	306.22	308.52
312.47	312.41	312.73	311.05	310.01	310.14	311.63	313.25	315.55
322.93	322.31	320.18	319.42	318.66	318.35	318.6	319.67	321.12
328.81	328.19	327.33	326.9	326.35	325.79	325.17	324.99	324.68
328.68	328.01	327.09	325.79	325.6	325.36	324.18	322.56	321.37
322.62	321.87	320.62	319.17	319.36	318.79	317.08	314.79	313.7
313.5	312.92	312.02	311.18	310.66	310.73	309.95	307.54	306.29
304.11	304.18	304.18	303.52	303.52	303.32	303.05	302.19	301.38
296.47	296.53	297.08	297.75	298.36	298.77	299.04	298.9	298.63
289.94	290.01	290.98	292.77	294.97	297.42	299.04	299.71	299.91
284.97	285.11	286.09	288.27	292.22	296.47	299.17	300.45	301.18
309.95	310.14	310.01	308.71	305.3	301.99	300.45	300.11	300.25
331	331.19	331.12	330.27	327.39	323.18	319.74	317.02	315.11
347.51	348.09	347.8	346.75	343.84	339.47	336.61	333.13	328.93

October Zonally Averaged Sound Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	394.87	394.82	394.62	394.42	394.16	393.85	393.49	393.14
115	353.77	354.56	355.36	355.47	354.62	352.86	350.68	348.78
110	330.88	329.11	325.91	321.43	316.19	310.73	305.96	302.39
105	303.05	300.85	297.55	293.53	289.52	285.95	283.26	281.34
100	274.45	274.01	273.57	273.28	273.28	273.79	274.38	274.89
95	256.32	257.8	260.14	263.22	266.64	269.94	272.54	274.16
90	255.76	258.19	261.76	265.8	269.94	273.28	275.55	276.72
85	264.36	266.86	270.39	273.64	277.15	279.69	281.05	281.98
80	281.27	282.84	284.75	285.04	286.52	287.22	287.29	287.92
75	294.22	295.17	296.19	295.17	294.35	293.05	291.19	290.08
70	303.18	303.58	303.78	302.78	300.85	298.63	296.26	292.84
65	308.65	308.58	308.71	308.26	306.95	305.5	303.58	301.72
60	318.16	316.25	314.27	313.05	312.22	311.63	310.92	311.96
55	328.07	324.68	321.43	320.3	320.24	320.56	320.74	322.06
50	335.42	331.67	328.38	326.65	327.52	328.25	328.62	328.62
45	338.23	334.09	329.66	327.45	327.39	328.25	328.74	328.87
40	337.99	332.28	324.61	320.49	320.24	320.93	322.56	323.62
35	329.17	323.62	315.74	310.92	310.4	312.02	314.15	315.49
30	312.73	309.95	305.7	302.19	301.58	303.65	305.1	304.91
25	295.38	297.82	301.58	300.78	299.64	298.7	297.89	297.42
20	290.15	292.22	295.24	297.42	296.6	293.53	290.91	289.66
15	286.02	289.18	293.6	296.67	295.51	290.98	286.59	284.19
10	287.78	290.22	293.87	297.82	300.92	304.51	308.19	309.88
5	306.42	308.91	312.8	317.21	322	326.35	329.42	330.94
0		331.79	333.67	336.14	339.65	343.02	345.59	347.22

October Zonally Averaged Sound Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
392.73	392.37	391.96	391.65	391.29	391.03	390.82	390.67	390.57
347.62	347.51	348.32	349.53	350.45	350.68	349.99	348.78	347.62
300.31	300.04	301.58	304.77	309.04	313.37	316.89	319.23	320.43
280.19	279.83	280.55	282.34	285.25	288.83	292.43	295.38	297.28
274.97	274.6	274.09	273.79	274.01	274.82	276.06	277.45	278.46
274.67	274.31	273.42	272.24	271.13	270.31	269.79	269.64	269.64
277.23	277.08	276.65	276.28	275.92	275.48	275.04	274.89	274.75
282.84	282.98	282.7	282.98	283.41	283.9	284.05	284.75	285.04
289.38	289.45	288.69	289.18	290.29	291.74	292.91	295.58	297.01
290.84	291.4	291.81	292.91	294.01	295.65	298.02	300.38	302.05
292.09	292.84	294.97	296.47	297.01	298.36	301.45	303.05	304.71
300.85	301.25	303.12	304.18	302.85	302.65	305.57	308.39	311.18
312.15	311.89	311.7	310.73	310.27	309.82	310.92	313.5	316.83
322.75	322.43	321.31	320.11	318.85	317.14	315.94	317.14	319.42
328.93	328.56	327.64	327.33	325.91	323	321.43	320.99	321.31
329.05	328.62	327.58	326.04	324.43	321.81	318.92	316.83	315.94
323.81	323.18	321.37	318.79	316.76	314.4	310.4	306.09	303.65
315.55	314.72	312.8	310.47	308.19	305.57	302.39	297.14	292.84
305.3	305.37	304.84	303.05	301.12	299.1	296.67	294.69	291.81
296.94	297.14	297.62	297.82	297.35	296.47	295.24	293.39	291.26
289.52	289.52	290.43	292.02	293.94	295.79	296.6	295.72	294.35
283.9	284.12	285.32	288.27	292.22	295.58	297.69	298.09	297.82
310.08	310.08	309.3	306.62	302.58	299.84	298.63	298.09	298.02
331.06	331.25	330.88	328.68	324.86	320.37	316.32	313.05	310.27
347.68	348.14	347.68	345.88	342.43	337.93	334.03	328.74	324.61

November Zonally Averaged Sound Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	395.44	395.18	394.82	394.31	393.65	392.93	392.11	391.24
115	355.64	356.15	356.55	356.21	354.9	352.68	349.93	347.33
110	338.52	335.78	331.43	325.91	319.74	313.5	307.8	302.98
105	309.82	306.68	302.32	297.35	292.57	288.41	284.9	282.12
100	274.67	274.23	273.79	273.57	273.72	274.23	274.82	275.11
95	249.71	251.96	255.37	259.67	264.36	268.67	272.09	274.01
90	244.41	247.93	253.23	259.44	265.8	271.13	274.75	276.57
85	250.27	254.11	259.44	265.58	271.87	276.86	279.97	281.77
80	269.27	271.43	274.16	277.08	280.98	284.33	286.45	288.06
75	287.64	288.41	289.04	289.04	289.66	290.22	290.56	290.43
70	301.92	301.45	300.31	298.97	297.89	296.67	295.38	293.19
65	311.31	310.34	308.91	307.86	306.55	305.04	304.18	303.18
60	323.18	321.06	318.22	316.51	314.53	313.76	312.99	314.15
55	332.04	329.91	327.45	325.79	324.55	322.87	321.62	322.12
50	338.05	336.02	333.85	332.34	331.61	330.94	329.66	327.95
45	338.46	336.67	334.87	333.67	332.88	331.37	329.66	328.31
40	334.45	332.34	329.48	327.95	326.9	324.99	324.24	323.81
35	325.67	323.56	320.56	317.78	316	315.17	315.36	315.94
30	315.17	313.25	310.01	306.03	303.98	304.31	304.71	304.31
25	307.99	307.41	304.64	302.32	299.64	298.36	297.62	297.21
20	306.88	305.57	302.98	299.04	295.38	292.09	289.87	288.9
15	301.79	301.32	299.98	297.96	294.42	289.87	285.81	283.34
10	294.15	295.31	297.01	299.37	301.85	305.1	308.52	309.95
5	308.06	310.08	313.82	318.66	323.49	327.39	330.09	330.94
0		329.72	332.46	335.96	340.19	343.48	346	347.45

November Zonally Averaged Sound Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
390.36	389.43	388.6	387.77	387.04	386.37	385.85	385.48	385.22
345.36	344.36	344.42	344.89	345.3	345.12	344.07	342.6	341.25
299.51	297.75	297.96	300.11	303.71	307.73	311.18	313.57	314.72
279.97	278.82	278.82	280.26	283.19	287.01	291.05	294.42	296.67
274.97	274.53	274.16	274.38	275.48	277.45	279.97	282.41	284.19
274.67	274.38	273.94	273.94	274.53	275.84	277.52	279.25	280.48
277.15	277.23	277.3	278.24	279.9	281.98	284.05	285.81	287.08
282.77	283.26	283.83	285.46	287.92	290.5	292.71	294.56	295.79
289.45	289.73	289.52	291.05	293.87	296.81	298.9	300.72	301.99
290.63	290.91	291.67	293.8	296.87	299.91	302.45	302.92	303.45
291.46	291.53	293.53	296.53	299.64	302.45	305.43	304.64	304.38
301.79	301.32	302.52	303.78	304.18	306.03	309.04	308.84	308.65
314.02	313.63	312.34	311.05	309.82	310.79	312.92	314.79	315.49
322.75	322.56	321.12	319.3	317.52	317.21	317.65	320.05	321.25
327.64	327.58	326.9	325.67	323.31	321.68	321.5	323.74	324.68
327.76	327.7	327.89	325.85	323.12	318.92	317.21	318.22	319.36
323.62	323.37	322.25	319.04	314.53	310.27	307.6	305.96	305.3
316	315.3	313.44	309.69	305.37	300.31	297.28	294.28	291.67
304.77	304.91	303.65	301.58	297.96	294.35	290.77	287.64	284.54
297.01	297.21	297.35	296.74	295.58	293.94	291.26	288.13	285.18
288.55	288.62	289.8	291.33	293.46	294.69	294.49	292.36	289.94
283.05	283.34	284.97	288.48	292.5	295.31	296.26	295.38	293.94
310.21	310.01	308.32	304.64	300.31	298.02	297.21	296.4	295.58
331.06	331.31	330.33	326.84	322.06	317.21	313.05	310.08	308.32
347.74	347.97	347.22	344.71	340.78	336.43	330.88	324.36	320.93

December Zonally Averaged Sound Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	395.79	395.49	395.03	394.31	393.49	392.52	391.49	390.36
115	356.83	357.22	357.34	356.77	355.19	352.68	349.59	346.58
110	343.84	340.24	334.87	328.56	321.75	314.98	308.71	303.32
105	315.17	311.12	305.7	299.91	294.49	289.8	285.81	282.48
100	275.99	275.33	274.67	274.23	274.31	274.67	275.11	275.26
95	246.87	249.47	253.39	258.19	263.37	268.14	271.8	274.01
90	238.74	242.84	248.9	256.24	263.67	270.01	274.31	276.35
85	242.76	246.95	253.15	260.91	268.74	275.26	279.25	281.19
80	262.22	264.13	267.01	271.58	277.23	282.41	285.53	286.94
75	283.41	283.62	283.9	284.47	286.02	288.06	289.73	290.15
70	301.05	300.31	298.9	296.74	294.97	293.87	293.8	294.01
65	314.59	313.12	311.05	308.65	305.89	303.78	303.98	305.57
60	327.52	325.17	322.18	319.55	316.57	315.23	315.3	317.52
55	336.55	333.91	330.88	328.44	325.91	324.12	323.06	324.12
50	341.07	338.76	336.19	333.79	332.1	330.39	329.11	327.58
45	340.13	338.52	336.79	334.81	333.61	331.31	328.99	326.65
40	334.51	333.25	331.49	329.72	327.76	325.85	323.62	321.93
35	325.73	324.74	322.62	320.3	318.35	316.64	314.85	314.02
30	314.15	314.08	312.67	309.62	307.47	305.5	304.51	303.45
25	308.45	307.93	306.22	303.32	300.85	299.17	297.96	297.35
20	308.39	307.01	303.91	299.24	294.76	291.53	289.45	288.41
15	305.63	304.44	302.25	298.29	293.26	288.69	285.39	283.41
10	299.78	299.44	299.51	300.38	302.78	306.29	309.17	310.14
5	311.51	312.86	315.42	319.8	324.68	328.38	330.52	331.06
0		330.7	332.82	336.61	340.95	344.48	346.58	347.74

December Zonally Averaged Sound Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
389.17	387.98	386.84	385.74	384.75	383.91	383.23	382.7	382.38
344.19	342.78	342.31	342.49	342.6	342.19	340.95	339.36	337.93
299.04	296.53	296.06	297.82	301.18	305.3	308.91	311.44	312.8
279.9	278.32	278.03	279.47	282.55	286.8	291.33	295.17	297.75
274.97	274.45	274.31	274.89	276.65	279.47	282.84	286.02	288.27
274.67	274.45	274.23	274.75	276.43	278.97	281.98	284.75	286.73
277.01	277.08	277.59	279.25	282.05	285.32	288.62	291.46	293.46
282.2	282.77	283.9	286.52	290.15	293.67	296.6	299.04	300.85
288.13	288.2	288.27	290.77	294.76	298.16	300.25	302.19	303.91
290.5	290.29	290.43	292.84	297.01	300.38	302.85	303.71	304.77
293.6	293.12	293.26	295.85	298.83	302.85	306.29	306.55	306.75
305.57	304.51	304.05	303.38	302.58	305.24	309.95	310.66	310.6
317.72	316.83	314.08	310.73	306.95	308.97	313.63	316.44	316.95
324.55	323.99	321.75	318.41	314.91	314.53	317.46	321.37	322.68
327.15	327.21	327.15	325.42	322.5	319.55	319.99	322.75	323.68
325.98	326.16	327.82	326.53	323.37	316.95	315.17	316.76	317.65
321.68	321.87	322.75	320.68	315.49	308.91	306.36	306.75	308.06
314.34	314.34	313.76	310.99	306.82	300.25	297.21	296.06	297.35
303.45	303.85	303.25	302.72	299.78	295.72	291.74	286.38	284.54
296.81	296.87	297.14	296.81	295.92	293.94	290.15	284.61	279.4
287.78	288.06	289.31	291.19	293.74	294.9	293.67	290.29	286.87
283.05	283.26	284.97	288.9	293.26	295.65	295.45	293.32	291.12
310.21	309.82	307.86	303.65	299.17	297.21	296.26	295.04	294.15
331.19	331.25	329.84	325.54	319.93	314.98	311.51	308.78	306.62
347.91	347.8	346.52	343.54	339.41	335.3	328.62	321.75	318.35

APPENDIX B: ZONALLY AVERAGED WIND SPEED (m/s)

The data are based on the COSPAR International Reference Atmosphere: 1986 (0 km to 120 km) Pages 134-157.

January Zonally Averaged Wind Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	-0.8	-1.5	4	8.6	10.4	8.2	-15.3	-26
115	-0.7	-1.2	4.7	10.4	13.9	14.3	-4.6	-14.7
110	0.7	1.5	9.5	18.1	25.6	31.3	21.6	12.9
105	4.4	8.9	19.6	30.7	40.5	48.5	44.5	36.2
100	7.2	14.1	25.9	37.1	46.3	54.1	50.6	42.2
95	5.8	11.3	21.7	31	37.6	43.2	39.2	32.2
90	0.6	1.2	7.5	13.2	17.2	22.3	20.2	17.5
85	-5.3	-10.3	-16.6	-14.2	-12.3	-4	5.1	7.6
80	-8.9	-17	-37.6	-44.4	-46.8	-30.3	-3.8	6.6
75	-11.2	-21.9	-48.7	-63.5	-68.9	-45.7	-7.8	10.9
70	-11.9	-23.6	-51.5	-67.5	-74.2	-52.3	-13.6	9.1
65	-11.1	-22	-47.7	-61.8	-69.5	-56.5	-27.1	-4.9
60	-9.3	-18.4	-42.1	-54.5	-63.5	-61.6	-45.9	-26.2
55	-6.9	-13.8	-36.1	-46.9	-57.7	-64.3	-62.7	-48.8
50	-4.3	-8.6	-30.1	-39.9	-52	-63	-69.5	-61.1
45	-2	-4	-24.5	-33.8	-45.5	-56.6	-63	-54.8
40	-0.1	-0.3	-19.1	-27.3	-37.5	-46	-50.3	-44.2
35	1.4	2.5	-14.1	-20.5	-28.2	-34.3	-37.9	-38
30	1.4	2.7	-9.5	-13.3	-18	-23.2	-27.3	-29.9
25	-0.8	-1.7	-4.7	-6.6	-9.2	-12.9	-17.9	-21.3
20	-0.3	-0.5	1.7	2.7	1.3	-2.7	-8.6	-11.8
15	1.9	3.7	9.6	16.3	17.6	12.1	4.5	-0.5
10	1.7	2.5	9.6	19.9	21.6	14.4	4.2	-2.2
5	0.1	0.4	8	15.7	13.4	6.2	0.1	-1.6
0		-0.2	2.6	5.4	2.6	-2.3	-4	-1.8

January Zonally Averaged Wind Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
12.1	34.9	14.8	-14.2	-23.6	-37.9	-28.3	-11.2	-5.7
15.6	31.5	10.3	-16.9	-25.8	-40.2	-30.4	-12.7	-6.5
27.8	29.1	6.9	-14.3	-21.7	-36.1	-27.1	-11.2	-5.6
40.1	29.9	7.5	-6.6	-11.7	-25.3	-18.4	-5.4	-2.7
42.2	28.8	8.4	-1.1	-3.6	-16.4	-10.7	0.2	0
34.2	24.4	8	2.4	2.4	-9.1	-3.8	5.3	2.5
24.8	21.1	10.5	9.3	11.6	1	4.6	11	5.5
24	27.3	19.5	24.4	24.9	13.4	9.8	15.6	7.8
25.7	31.7	27.3	38.6	38.5	22.6	10.3	17.7	8.9
28.1	37.5	37.5	50	51.4	27.6	11.5	17.1	8.8
26.1	39.7	45.8	59	60.4	31.8	13.1	17	8.6
11.2	32.5	46.6	61.2	62.5	36	16.7	19.5	9.7
-9.9	15.1	36	54.3	58	39.8	23.9	26	12.8
-30.1	-6	19.3	41.7	50.5	43.3	32.2	34.4	17
-41.5	-17.8	7.6	31.2	43.2	43.7	36.6	39.5	19.8
-37.5	-15.4	4.9	23.8	34.5	39.3	36.5	39.9	20.4
-33.4	-11.4	4.9	16.3	25.1	33.8	35.7	39.2	19.9
-35.3	-12.1	1.6	8.8	18.4	30.1	36	37.8	19.3
-30.6	-11.2	-0.8	4.9	14.7	26.7	34.2	33.7	17.5
-19.5	-6.7	1.2	5.6	12.9	21.9	27.6	25.5	13.4
-10.3	0.6	7.7	11.1	15.8	19	20.7	18	9.3
-1.5	12.9	24.5	28.2	26.6	20.6	17.6	13.2	6.8
-2.5	4.6	21.4	33.4	26	16	10.2	7.2	3.6
-3.3	-1.8	8.3	15.4	14.8	10.3	6.2	4.1	2.3
-2	-5.1	-4.1	1.1	3.5	2.5	0.5	0.2	-1.2

February Zonally Averaged Wind Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	-0.1	-0.1	11.2	19.7	19.2	12.1	-8.7	-22.2
115	-0.1	-0.2	11.5	20.8	21.7	17	-0.2	-13.1
110	1	1.8	15.3	27.5	32.3	32.3	22.1	10.4
105	3.8	7.4	23.4	38	45.1	46.9	40.2	28.9
100	5.8	11.5	28.3	42.7	49.1	50.1	43.4	31.7
95	4.8	9.3	24.6	36.9	40.6	39.3	32.1	21.3
90	0.6	1.1	13.2	22.2	23.5	21.9	16.4	8.9
85	-6	-11.3	-4	1.3	1.7	5	3.4	0.9
80	-9.5	-18.6	-17.6	-20.5	-20.4	-7.9	-1.1	-2.4
75	-11	-21.5	-25.3	-35.2	-34.5	-14.7	1.8	1.7
70	-11.1	-22	-26.9	-39	-38.6	-18.6	1.4	4.3
65	-9.2	-18.5	-23	-34.6	-37.8	-24.4	-4.2	2.3
60	-6.3	-12.7	-16.9	-28.3	-36.4	-31.8	-13.8	-3.2
55	-3.9	-7.8	-11.8	-22.4	-34	-36.5	-27	-18.4
50	-2.1	-4.1	-8	-17.6	-30.5	-37.6	-37.9	-35.7
45	-0.8	-1.5	-5.6	-14.6	-26.9	-35.8	-41.3	-41.5
40	0.2	0.5	-3.4	-11.9	-22.5	-31.6	-40.9	-43.1
35	1	2	-1.6	-8.6	-17.6	-26.7	-37.8	-42.2
30	1.3	2.6	0.3	-4.4	-12	-21.5	-31.5	-35.5
25	1.5	2.9	2.9	-0.3	-6.9	-14.7	-23.2	-28
20	3.1	6.2	8.2	6.7	1.8	-5.8	-13.6	-18.7
15	4.6	8.9	16.6	18.5	16.5	8.9	1	-6.7
10	4.9	7.8	15.6	22.8	20.6	13	3.5	-2.5
5	2.6	3.3	10.5	16.2	12	4.3	-0.5	-1.8
0		1.2	4	5.5	1.7	-3.1	-4.2	-1.4

February Zonally Averaged Wind Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
-8.1	14.6	20.2	9.8	-1.2	-23.2	-27.8	-15.2	-7.8
-3.8	14	18.4	9	-2.4	-24.9	-29.6	-16.7	-8.6
10.1	17.8	20.5	14.2	2.5	-20.9	-27	-15.7	-7.9
21.2	21.2	24.3	21.8	11.7	-11.7	-19.4	-10.7	-5.4
21.1	19.4	24	25.1	17	-5.5	-13.7	-6.5	-3.3
12.2	13.1	20.8	24.6	18.4	-2.8	-10.7	-3.9	-2
3.7	8.8	20.2	26.4	21.5	1.1	-6.9	-1.3	-0.6
1.4	12.3	26.2	33	32	7.6	-2.8	2.8	1.5
0.8	17.7	32.4	40.5	47.5	14.8	-0.5	6.3	3.2
6.8	29	41.8	49.4	55.3	22.8	1.3	5.9	3
11.1	37.4	50.8	57.3	62	29.7	3.6	5.6	2.8
8.1	36.7	52.4	61.2	66.6	36.3	9	9	4.5
0.6	25.7	44.4	58.7	67.9	42.5	18.1	16.5	8.1
-12.9	8.6	31.2	50.7	64.8	47.5	28.4	25.5	12.6
-26.4	-4.8	19.3	41.9	58.9	47.5	33.3	30.7	15.5
-32.7	-9.7	12.2	33.3	50.3	41.3	30.3	29.6	15.3
-36.4	-11.9	7.3	24.2	38.5	32	24.7	26	13.4
-38.3	-13.3	3	14.6	25.8	24.4	22.7	24	12.2
-33.4	-11	1.4	7	14.9	19.6	23.6	23.6	12
-24.9	-8.1	2.1	5.2	10.4	16.9	22	21.5	11
-15.6	-1.3	7.4	10.4	14.2	16.5	18.3	16.4	8.4
-6.6	11.1	24	28.2	25.5	18.8	15.5	11	5.7
-3.2	4.3	23.2	35.2	26.2	14.7	9	7.1	4.9
-3.7	-1.8	9.4	16.3	14.3	9.4	5.5	3.7	2.6
-2.3	-5.2	-4.1	1.2	3.2	2.3	0.1	0.2	-0.3

March Zonally Averaged Wind Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	7.1	14	19.7	21.2	18.7	13.3	12.8	25.9
115	6.7	13.3	19.3	21.4	19.9	16.2	17.4	31
110	7	13.9	21.5	26.4	28.2	27.6	31.6	46.2
105	8.8	17.6	27.6	34.8	38.3	38.8	43.2	57.6
100	10.4	20.5	31.3	38.5	41.4	40.4	43.9	57.2
95	10	19.6	29	34.3	34.8	32.2	34.8	48
90	7.8	15.2	22.1	25.1	24.2	21.5	24.9	39.4
85	5.1	10	14.2	14.2	15.3	13.9	16.5	32.8
80	4.9	9.5	11.1	7.7	11.9	12	10.3	19.4
75	5.6	11	11.9	6.8	10.9	13.7	12.9	15.2
70	6.4	12.8	14.6	9.7	10.5	13.2	16.6	18.8
65	8.4	16.6	19.8	14.1	7.6	9.1	19.4	25.1
60	10.7	21.3	25.1	17.9	4.5	3	17.5	25.9
55	12.6	25	27.9	19.6	3.2	-0.9	9.3	14.8
50	13.4	26.5	28.3	19.4	2.6	-1.8	1.4	0.5
45	12.8	25.1	25.8	17.6	2.6	-3.3	-5.2	-9.3
40	11.3	22.1	20.9	14.1	2.5	-6.1	-12.9	-18.3
35	9.7	18.8	15.6	10.5	1.3	-8.9	-17.9	-24.4
30	8	15.6	12.3	8.4	-0.2	-10.4	-18.4	-24.1
25	5.9	11.7	11	7.8	-0.2	-9.1	-16.4	-20.4
20	5.7	11.4	11.8	10.8	5.5	-2	-9.1	-14.4
15	6.5	12.9	16.1	19.2	18.1	13.5	6.4	-3.3
10	6.3	9.7	16.8	23.1	21	15.4	5.5	-2.6
5	3.5	5.7	12.4	16.7	12.6	6.2	0.3	-2.4
0		-1.3	4.9	6.8	2.7	-2.9	-4.3	-2.4

March Zonally Averaged Wind Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
45.7	21.2	3.8	11.4	12.8	12.8	20.6	21.4	11
50.1	24.1	6.1	13	13.3	12.4	19.6	20.5	10.6
64	35.1	15.9	22.1	20.2	16.7	21.6	20.9	10.6
74.1	43.4	24.3	31.5	29.5	24.8	27.2	24.1	12.1
72.6	42.1	23.9	32.9	32.6	28.5	30.6	26.8	13.6
63.1	33.7	16.7	27.2	28.5	25.9	29.7	26.8	13.7
55.4	26.8	10.4	21.3	22.8	21.1	26.1	24.7	12.6
48.7	23.8	5.8	18.4	15.9	20.3	23	22.3	11.4
31.6	17.7	5.1	17.2	11.2	26.8	22.7	20.6	10.6
26	23	16.3	22.5	17.3	31	23.5	17.9	9.2
28	34.5	30.9	29.9	25.1	33.9	22.3	14.4	7.4
32	41.8	39.9	34.5	31.7	35	21.4	12.7	6.5
27.6	37	39.5	35.4	36.3	35.5	22	14	7
14	24.6	32.9	33.3	37.3	35.8	25.2	18.3	9.2
1	13.5	25	30	36.1	35.2	27.2	21	10.7
-9.9	5.6	18.1	26	33.2	32.2	25	19	9.8
-18.5	-1.4	10.9	20.6	28.4	26.2	18.8	13.8	7.1
-23.5	-7.2	4.1	14.4	21.4	18.6	13.4	10	5.2
-22.4	-7.9	1.2	7.8	12.4	12.2	11.5	10.2	5.1
-18.9	-6.3	1.2	4.2	7.2	9.8	11.9	12.1	6.1
-14.7	-1.8	5.9	8.6	10.8	11.3	12	11.1	5.7
-7.1	10.1	23.1	26	21.8	14.8	11.2	7.1	3.6
-4	3.3	20.7	31	24.1	14.3	10.7	8.5	4.6
-4.1	-2.6	7.8	14.8	13	9	7.1	5.2	2.2
-1.9	-4.8	-4.1	0.4	2.7	2	0.9	0.2	-1.3

April Zonally Averaged Wind Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	-0.4	-0.9	4.8	14.4	14.4	4.5	20.3	43.3
115	-1.1	-2.3	3.4	13.4	14.1	4.9	20.8	44.6
110	-1.2	-2.3	4.6	16.7	19.8	11.9	27	51.8
105	0.7	1.4	10.4	24.5	28.5	20.8	33	57.5
100	2.4	4.8	14.7	29	32.2	23	32.9	55.9
95	2.9	5.8	15.3	28.6	30.4	19.5	27.5	48.7
90	2.7	5.4	14.6	27.5	28.7	16.9	23.8	43.2
85	3.4	6.8	15.6	29.4	31.3	18.3	22.4	39.3
80	5.9	11.8	19.7	35.8	38.2	21.8	14.2	18.7
75	8.7	17.3	26.6	43	45.1	29.8	15.9	10.1
70	10.5	20.9	33.2	50.6	50.9	37.3	26.1	18.2
65	12.8	25.5	40.4	57.2	53	41.9	38.9	32.8
60	15.7	31.6	47.7	61.3	53.2	42.4	44.3	38.5
55	18.8	37.4	52.3	62.2	52.9	40.3	40.8	33
50	20.9	41.5	54.3	59.7	48.7	37.3	36	25.5
45	21.4	42.2	52.7	54	41.7	32	28.8	17.4
40	20.5	40.2	46.5	45.1	33.3	23.1	16.7	5.8
35	19.1	37.2	37.4	34.2	23.7	12.4	2.5	-8.4
30	17	33.1	28.9	24.1	14.2	3.5	-7.6	-17.5
25	12.4	23.5	22.1	17.8	9.3	-0.4	-9.7	-16.3
20	8	15.4	17.4	16.5	11.6	3.9	-3.6	-10.1
15	6.8	13.6	16.8	20.8	21.7	18.4	13.3	3.1
10	7.5	8.3	14	21.6	21.7	19.2	11.5	0.4
5	3.5	4.3	10.9	16.4	13.3	8.4	2.8	-2.3
0		1.9	6	6.9	3.6	-1.3	-4.1	-3.7

April Zonally Averaged Wind Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
38.9	-10.7	-22.7	2.1	17.7	21.1	23.3	19.7	10
43.2	-3.7	-16.1	6.2	19.7	21.7	23.2	19.3	9.8
56.7	15.6	2.5	19.7	29	27.7	26.1	20.3	10.2
66.9	30.7	17.5	32.1	39.9	36.7	32.7	24.3	12.2
65.9	31.7	18.9	33.6	42.5	40.2	36.2	27.2	13.8
56.6	21.5	7.9	23.4	34.2	34.6	32.9	25.8	13.3
48.6	10.6	-5.3	9	20.1	22.3	23.6	19.9	10.3
40.3	1.9	-18.2	-6.3	4.6	9	11.7	12.4	6.4
15.3	-12	-26.8	-19.5	-7.7	3.8	6.9	10.2	5.2
5.4	-12	-19.4	-19.7	-9.6	4.2	7.2	9.7	5
14	6.1	-2.1	-13.8	-5.9	6.9	7.9	9.5	4.8
28.4	25.9	12.7	-7.8	-2	9.1	8.6	9	4.6
31.1	29.1	17.1	-2.5	1.2	10.5	9.1	8.1	4.1
21.4	19.3	13.8	1.8	4.7	11.9	10.4	8.5	4.3
12.4	11.1	10.1	4.8	7	12.5	10.9	8.6	4.3
5.6	6.7	8.5	6.7	8.8	11.8	9	6.3	3.3
-3	0.4	5.6	8.2	10.3	8.9	4.2	1.7	0.8
-13.1	-8.2	0.6	8.4	9.9	4.3	-1.8	-3.5	-1.8
-19	-10.8	-1.4	5.5	6.5	0.4	-5.5	-6.7	-3.4
-16.1	-7.1	-0.9	2.6	3.5	0.1	-3.7	-4.8	-2.5
-9.4	-0.6	4.2	5.4	6.7	3.7	0.1	-1.4	-0.7
-0.2	13.3	22.1	20.5	17.1	9.5	3.1	0.3	0.2
-3	3.9	17.7	24.5	21.3	15.2	10.7	7.4	3.1
-3.9	-2.3	5.6	11.2	11.5	9.5	7.3	4.8	1.3
-2	-4.1	-4.4	-1.5	1.6	2.4	0.6	-0.5	-1.1

May Zonally Averaged Wind Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	2.4	4.6	-10.3	-15.6	-11.1	-11.6	5	14.9
115	1.6	3	-12.4	-17.4	-12.5	-13.2	1.9	13
110	1.7	3.4	-10.4	-14.1	-8.4	-9.8	1.1	13.7
105	4	8.1	-3.1	-5	0.9	-2	3.2	15.8
100	6.2	12.4	3.3	2.2	7.4	2.5	3.7	14.7
95	7.9	15.9	7.9	6.9	10.9	3.8	1.8	9.3
90	9.9	19.9	13.7	13.5	17.3	8.3	2.7	5.4
85	12.3	24.8	19.9	22.5	29.3	17.6	10.7	7.5
80	15.3	30.7	24.9	29.4	45.2	27.4	11.3	-4
75	17.9	35.5	30	38.4	58.6	42.8	18.5	-6.1
70	18.8	37	33.8	49.2	72.4	60.6	35.8	10.4
65	18.7	36.5	37	60.4	84.2	75.3	54.7	30.4
60	18.6	36.6	41	70.8	91	81.1	62	37.2
55	19.5	38.7	46.3	78.6	93.3	78.7	57.6	30.8
50	20.8	41.3	51.6	81.5	89.7	72.3	50.9	23.1
45	21.9	43.3	54.7	77.2	79	62.4	43.8	20.4
40	22.3	44.2	54.2	67.1	62.9	47.4	32.9	15.5
35	22.9	45.3	51.5	54.4	43.6	28.9	16.7	3
30	23.1	45.2	46.2	40.2	26	13.6	2.8	-9.1
25	19.1	36.1	35.7	28	15.7	6.2	-1.9	-10.4
20	12.9	24.5	25.7	20.8	13.9	8.3	3.2	-3.6
15	9.4	18.3	19.2	19.3	20.9	22.6	21.2	9.7
10	7.1	9.7	13.6	19.7	22.4	23.6	18.1	4.2
5	4.1	5.2	9.5	14.8	14.6	11.3	6.3	-0.6
0		1.4	4.4	4.7	2.9	0.1	-3.7	-4.3

May Zonally Averaged Wind Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
-11.8	-47.3	-27.6	15.8	24.5	15.1	8.9	4.7	2.4
-8	-36.7	-17.7	21.2	27.5	16.6	9.4	4.9	2.5
5.1	-10.2	6.8	37	38.1	23.6	13.5	7	3.5
16.5	10.9	27	52.1	51.2	34.5	22.1	12.9	6.4
18	15.6	31.5	55.8	55.7	39.9	27.5	17.3	8.8
9.4	4.7	19.3	44.4	47.2	33.9	23.5	14.9	7.7
0.5	-9.4	1.1	25.1	28.6	17.7	10.8	6.1	3.3
-4.8	-21.6	-18	3.3	2.6	-5.5	-9.4	-8	-4.2
-22.6	-39.2	-36	-18.1	-23.1	-23.1	-22.7	-16.8	-8.6
-27.9	-43.9	-40.5	-27.9	-32	-28.6	-27.4	-21.8	-11.2
-10.2	-26.2	-31.7	-28.8	-31.9	-26.7	-26.8	-23.3	-11.8
9.9	-6.1	-20.6	-27	-28.8	-22.8	-24.1	-22.4	-11.4
14.3	-1.7	-17.5	-25.9	-24.4	-18.1	-20.9	-19.8	-10
5.5	-9.8	-19.4	-23.3	-18.9	-13.9	-17.1	-15.8	-8
-2.7	-13.4	-18.4	-19	-14.1	-10.9	-13.9	-11.7	-5.9
-2.5	-9.9	-13.6	-13.7	-9.9	-8.9	-12.1	-9.6	-4.8
-4	-9.8	-10.3	-6.9	-5.4	-7.5	-10.8	-8.8	-4.4
-11.4	-15.3	-10.6	-2.5	-2	-6.4	-9.5	-8.9	-4.5
-18.2	-17.6	-9.9	-2	-1.7	-5.2	-7.6	-7.9	-4
-15.6	-12.3	-7.1	-3.1	-2.3	-3.6	-4.8	-5	-2.5
-7	-3.1	-0.6	0.4	2.1	1.1	-0.4	-0.8	-0.4
1.3	9.3	16.3	15.3	13.7	8.9	5	3.3	1.6
-2.4	0.9	10.9	18.9	17.5	14.2	9	5.9	4.2
-3.5	-2.9	3	8	9.1	8.8	6	4.3	3.5
-1.8	-2.6	-3.9	-1.7	1.5	2.1	-0.2	-0.4	-0.6

June Zonally Averaged Wind Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	4.3	8.4	-17.5	-30.9	-26.5	-21.3	-3.7	9
115	3.5	6.8	-19.6	-32.9	-28.3	-23.9	-8.6	5.4
110	3.9	7.9	-16.8	-29.1	-24.8	-22.4	-13.2	2.4
105	6.5	13.3	-8.1	-18.6	-14.4	-14.8	-12.8	2.7
100	9.1	18.6	-0.2	-9.4	-5.7	-8.6	-11.7	1.9
95	11.7	23.6	7.2	-1.3	1.1	-4.5	-11.6	-2.4
90	14.5	29.3	16.2	9.6	11.7	3.5	-8.2	-5.4
85	17.2	34.5	23.6	20	27.5	17.9	3	0.4
80	19	38.1	27.5	24.3	45	31.1	6.7	-3.7
75	21	41.9	30.7	31.8	59.8	48.5	15.1	-6.3
70	22	43.7	32.8	41.4	76.9	70	32.1	4.4
65	22.5	44.3	34.8	52.5	92.8	89.5	50.6	16.5
60	22.8	45.2	38.3	63.3	103.7	99.6	58.5	20.9
55	24.1	48.3	44.4	72.8	109.6	99.8	54.7	15
50	26	51.8	50.7	79.1	109	93.7	49.2	11.1
45	27.1	53.5	54.8	78.5	99.8	82.3	44.5	13.7
40	27.1	53.3	57.2	72.8	82.8	64.2	36.3	13.1
35	27	53	60.5	65.5	59.8	39.9	19.9	2.5
30	26.4	51	59.9	54	37.1	19.8	5.5	-8.5
25	21.7	41.2	48.5	39.6	22.5	10.4	2.3	-8.1
20	16.1	30.8	35.8	29.2	18.2	11.9	6.8	-1.5
15	11.2	21.5	26	23.5	23.3	26.9	22.5	9
10	6.6	11	14.4	19	23.9	27.6	18.9	2
5	2.7	4.1	8.9	13.8	14.4	12.6	7	-1.4
0		2.8	5.9	5.7	3.8	0.3	-4.2	-5.1

June Zonally Averaged Wind Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
-12.8	-58.1	-35	15.1	18.5	6	-0.7	-5.7	-2.9
-9	-45.3	-23.4	21.4	22	7.8	0.1	-5.4	-2.8
3.2	-16	4.2	38.5	33.4	15.6	5.2	-2.3	-1.1
15.9	9.4	28	55.6	47.9	28	15.3	5.3	2.6
19.2	17.5	35.4	60.9	54	35	22.2	11.2	5.7
11.3	6.9	23.1	50.3	46.3	29	18	8.2	4.3
1.8	-9	2.6	29	26.1	11.2	3.5	-2.2	-1.2
-1.9	-22.1	-18.1	1.2	-4.3	-15.1	-21.5	-21.2	-11.1
-14.8	-36.7	-34.9	-29.9	-38.7	-39.4	-43.2	-33.3	-17.2
-24.9	-41	-40.3	-46.6	-55.6	-54.2	-53.8	-38.2	-19.5
-18.3	-31.3	-37.6	-51	-59.4	-56.2	-54.7	-39	-19.7
-11.1	-24.4	-35.9	-48.1	-55.9	-51.5	-50.3	-36.9	-18.6
-10.1	-26.4	-40	-45.8	-50.3	-45.1	-44.5	-33.1	-16.7
-14.6	-32.8	-43.4	-43.5	-43.3	-38.8	-38.9	-27.9	-13.9
-16.3	-33.7	-42.1	-40.4	-35.9	-33.5	-33.8	-22.1	-11.1
-11.5	-26.2	-35	-33.8	-29.5	-28.4	-28.4	-17.5	-8.8
-11.4	-21.2	-26.7	-25.1	-22.4	-22.4	-22.6	-14.3	-7.2
-19.1	-23.2	-21.4	-18	-15.8	-16.1	-16.8	-11.9	-6
-23.3	-23.3	-17.8	-13.3	-11.1	-11.3	-11.7	-9.6	-4.8
-17.9	-17.1	-14	-10.5	-8.1	-7.7	-7.5	-6.3	-3.1
-8.9	-9.1	-8.1	-5.1	-1.8	-1.7	-2.1	-1.9	-1
-3	-0.1	4.1	8.8	12.1	7.6	3.9	2.7	1.3
-5.7	-5.2	1.2	12.6	16.4	12.2	7	5.3	2.8
-4.3	-4.3	-1.1	5.5	8	7.3	4.7	4.2	2.5
-2.2	-1.3	-3.5	-0.9	1.5	1.8	0.6	-0.5	0.3

July Zonally Averaged Wind Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	5.9	11.6	-6	-31.2	-33.7	-18.9	7.6	14
115	5.2	10.1	-7.8	-32.9	-35.3	-21	3.4	11
110	5.6	11.2	-4.9	-28.6	-31.3	-19	-0.3	8.9
105	8.1	16.1	3.2	-18.2	-20.8	-11.4	0.7	9.7
100	10.5	21.1	10.4	-9.5	-12.6	-5.4	1.6	8.6
95	12.8	25.7	16.9	-2	-6.3	-1.9	1.2	4.2
90	15.4	30.9	25	8.4	3.9	5.6	4.1	1.2
85	17.6	34.9	32	17.9	18.4	19.8	15.7	7.5
80	18.1	35.8	36.2	21.6	32.4	33.5	24.6	10.6
75	18.9	37.5	38.3	28.3	44.9	45.8	33.3	15.1
70	20	39.6	40.5	37	58.6	59	43	20.8
65	21.4	42.8	44.7	48.1	72.5	69.4	48.5	21.4
60	23.7	47.7	51.7	60.2	83.4	73.6	44.9	14
55	26.9	54.2	61.2	72.3	89.8	71.2	35.5	2.4
50	29.7	59	69	80.3	90.3	66.2	28.2	-3.3
45	30.5	59.9	72.6	81.7	84.5	58.8	25	-0.6
40	29.8	58.4	74.1	80	74	47.4	20.3	-1
35	28.9	56.6	76.1	76.9	59.7	31.6	9.9	-9.2
30	27.6	53.8	74.8	67.7	42.9	18.1	1.7	-14.2
25	23.4	44.8	62.6	51.6	29.5	12.2	1.9	-9.6
20	18.6	35.7	47.1	37.9	24	13.9	7.5	-1.5
15	13.4	25.8	34.6	28.9	26.5	27.8	22.4	7.6
10	7.3	9.5	11.8	17.4	24.8	29.2	18.7	1.3
5	3.3	3.7	7.6	12.6	14.6	13.3	6.8	-1.7
0		1.9	6	6.9	5.1	0.7	-4.5	-5.4

July Zonally Averaged Wind Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
-16.6	-38.4	-17.9	13.6	19.3	11.4	-2.2	-11.2	-5.7
-12.4	-26.4	-6.8	19.8	22.9	13.3	-1.5	-11.1	-5.6
0.1	1.3	19.3	36.4	34.1	20.7	3.2	-8	-4
12.6	24.8	42.2	53.5	48.4	32.8	13.3	-0.4	-0.2
15.3	31.5	49	58.9	54.4	39.4	20.2	5.4	2.7
7	21.1	37.3	48.3	46.4	33.6	16.1	2.2	1.1
-2.3	6.2	17.8	27.5	26.5	16.7	2.3	-8.3	-4.4
-3.5	-4.6	-1	3	-1.4	-11.3	-22.5	-26.2	-13.9
-1.7	-8.7	-13.5	-20.5	-34.2	-43.6	-45	-38.5	-19.9
0.9	-5.1	-15.3	-35.6	-58.4	-64.8	-57	-44.7	-22.9
5.2	-1.8	-15.4	-41.6	-65.6	-70.5	-59.2	-46.1	-23.3
1.1	-6.6	-20.5	-44.3	-62	-64.8	-54.2	-42.5	-21.4
-8	-16.4	-29.9	-47.6	-56.6	-56.2	-47	-36.7	-18.4
-18.2	-28.6	-39.2	-49	-51.5	-47.8	-39.9	-30.3	-15.3
-23.5	-35.4	-43.8	-47.4	-46.1	-40.6	-33.4	-23.9	-12.1
-19	-30.3	-40.5	-42.1	-39.7	-34.3	-27.4	-18.6	-9.4
-19.2	-25.8	-33.5	-33.8	-31.5	-26.9	-21.2	-14.7	-7.4
-28.9	-27.9	-28	-25.7	-23.2	-19.4	-15.5	-11.7	-5.9
-30.4	-26.8	-24.1	-19.6	-16	-13.3	-11.1	-9.1	-4.6
-21.3	-20.9	-19.1	-14.7	-10.9	-8.8	-7.3	-5.8	-2.9
-11.2	-12.7	-12.6	-8.5	-3.6	-2.1	-2.1	-1.8	-0.9
-5.1	-4.6	-2.9	2	10.9	8.3	4.2	2.5	1.3
-6.2	-6.3	-3.4	3.8	15.8	13.6	7.4	5.6	4.4
-3.8	-3.8	-3	1.5	7.3	7.6	4.4	4	3.9
-2.3	-0.4	-3.8	-1.9	0.9	1.9	0.8	-0.1	0.1

August Zonally Averaged Wind Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	11.1	21.5	-2.5	-25.1	-16.3	4.3	13.8	-1
115	10.4	20.3	-4	-26.5	-17	3.5	12.2	-2
110	10.5	20.9	-1.6	-22.4	-12.3	7.9	13.4	0.6
105	12.3	24.8	5.3	-13.3	-2.8	15.8	17.1	4.2
100	14.2	28.3	10.6	-6.9	3	19.4	17.2	2.8
95	15.5	30.8	13.7	-3.7	4.8	19.2	14.2	-3.5
90	16.6	33.1	17.5	0.9	8.8	21.5	14	-7.7
85	17.9	35.3	21.4	7.3	17.8	30.4	19.7	-3.8
80	18.2	35.7	23.3	10.9	29.4	41.7	28.2	3.9
75	18.2	36	24.5	16.6	37.9	50.6	42.3	18.3
70	18.7	37.1	24.8	21.5	45.6	59.5	54.1	29.5
65	20.6	41.8	27.2	27.1	52.5	65.2	57.2	30.7
60	24.6	50.5	34.1	34.5	57.1	64.9	49.9	21.8
55	29.7	61	45.8	44.1	57.9	58.5	37.9	7.4
50	34	68.7	57.1	52.3	55.2	49.2	27.5	-2.5
45	36.3	71.8	64.3	57.1	50.3	38.9	19.5	-6.1
40	36.7	71.9	69.3	60.8	45.1	27.6	10.2	-10.9
35	35.8	70	73.4	64	40.2	16.5	-0.1	-17.6
30	33.8	65	72.9	61.1	32.9	9	-5	-19.6
25	28	52.5	61.8	49.3	25.1	7.5	-2.2	-13.9
20	20.2	38.3	46.5	37.2	21.7	11.7	5.5	-5.5
15	14.3	27.3	32.1	27	24.9	26.9	21.2	2.7
10	9.4	10.5	14.2	19.9	25.8	29.5	18.3	1
5	4.6	4.7	9.3	13.9	14.8	13.7	7	-1.8
0		0.1	3.3	5.8	4	-0.3	-4.7	-5.5

August Zonally Averaged Wind Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
-22.5	-31	-8.7	20.5	26.5	17.6	4.3	-8.8	-4.5
-18.2	-21.5	0.1	25.2	29.2	18.9	4.6	-8.9	-4.6
-4.8	2.5	22.4	40.4	39.4	25.3	8.5	-6.9	-3.4
6.7	21.2	40.8	54.9	51.8	35.8	16.9	-1	-0.4
7.3	24.3	44.3	58.3	55.8	40.9	22	3.3	1.7
-1.7	13.6	32.5	47.5	47.7	35.3	18.2	0.6	0.3
-10.2	1	16.5	29.8	30.4	20.4	6.3	-8.2	-4.4
-11.6	-6.9	2.9	11.9	8.3	-1.8	-11.1	-23.3	-12.4
-8.3	-6.9	-3.2	-2	-15.9	-25.1	-24.8	-34.4	-17.8
0.6	1.4	0.3	-9.2	-32.1	-40.3	-34.2	-39	-19.9
8.2	8.2	3.4	-12.9	-38.6	-45.1	-36.9	-38.9	-19.6
6.5	9.9	3.4	-17.3	-39.3	-41.6	-33	-32.9	-16.5
0.3	7.8	0.2	-23.5	-39.1	-36	-26.4	-24.3	-12.2
-11.3	-3	-8.4	-28.5	-37	-30.5	-20.4	-17.6	-8.9
-20.9	-16.2	-17.8	-30.7	-34	-25.8	-16.4	-12.9	-6.6
-24.4	-20.5	-22.1	-30.2	-29.8	-21.9	-13.2	-9.8	-4.9
-28.9	-24	-24	-26.3	-24.3	-17.6	-10.1	-7.2	-3.7
-34.9	-28.5	-25	-21.9	-18	-13.1	-7.2	-5.3	-2.7
-34.4	-27.5	-23.5	-18.3	-12.3	-8.5	-5.2	-4	-2
-25	-21.6	-18.9	-14.1	-8.4	-5.1	-3.2	-2.1	-1
-15.9	-14.6	-12.4	-7.8	-1.7	0.5	0.7	0.6	0.3
-12.7	-8.3	-3.2	2.3	12.1	10.6	6.2	4	2.1
-6.8	-6.9	-3.6	4	16.2	15.6	9.1	6.9	4.3
-4.2	-4	-3.2	1.3	7.6	8.6	5.4	4.7	3.2
-2.3	0	-3.3	-2	1	2.1	0.5	-0.1	0.1

September Zonally Averaged Wind Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	3.7	7.2	5.2	3.5	7	6.9	2	-10.6
115	3.2	6.2	4.2	2.8	7.2	8.1	3.8	-8.2
110	3.4	6.6	6	6.9	13.8	16.7	12.9	2.1
105	5.1	10.1	12	15.2	23.4	26.6	21.5	10.6
100	6.6	13	15.9	19.4	27.1	28.9	21.9	10
95	6.7	13.1	15.2	17.5	23.5	23.6	15.1	1.8
90	5.8	11.3	12.1	13.3	18.5	18.2	9	-5.3
85	4.1	7.8	9.5	10.7	18.2	18.5	6.2	-7.2
80	2	3.7	9.5	13.1	23.7	22.9	5.2	-8.5
75	0.6	1.1	10.4	18.4	30.3	32	15.5	1.8
70	-0.8	-1.6	9.2	22.7	38.3	43.2	29.3	16.8
65	-0.5	-0.8	9.1	26.1	44.8	50.7	38	26.6
60	2.6	5.5	12.3	29.4	48.2	53.3	37.9	23.7
55	8	16.9	20.5	33.1	47.2	50.2	32.5	13.7
50	13.9	28.6	29.6	35.7	42.8	43.8	25.8	5
45	18.5	37.4	37.5	37.8	37	34.9	19.2	-0.9
40	22	44.5	46.2	41.5	31.2	23.6	10	-7.2
35	25.3	50.6	56.8	46.8	26.2	11.5	-0.7	-13.8
30	27.1	52.9	63.5	49.8	21.5	2.8	-7	-16.2
25	24.4	46.8	59.1	45.3	19.2	2.3	-5.8	-13.2
20	20.1	38.8	46.3	36.4	20.5	9.3	2.7	-5.5
15	15.5	29.8	32.4	27.5	26.4	26	19.5	4.8
10	7	10.9	17.3	23.3	25.8	27	17.1	1.9
5	2.9	4.8	11.4	16.6	16	12.8	5.8	-1.9
0		2.1	5.8	5.9	3.5	-1.1	-4.4	-5.2

September Zonally Averaged Wind Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
-20.7	-18.5	-4.7	14	23.7	20.6	14.4	11.5	5.9
-16.9	-13.4	0.1	16.8	25	20.8	14	10.9	5.6
-3.3	3	15.3	28.4	33	25.5	16.2	11.5	5.8
7.5	16.1	28.1	40.1	43.6	34.1	22.4	15.2	7.7
7.3	17	29.6	42.4	46.9	38	26.4	18.3	9.3
-1.9	7.6	20.2	34.1	40.7	34.3	24.2	17.4	8.9
-10.1	-1.9	9.4	22.7	29.7	24.7	16.9	12.7	6.6
-13.9	-7.6	1.3	15	20.5	12.6	7.2	6.3	3.3
-18.6	-13	-2.6	12.2	15.6	3.3	1.9	4.2	2.2
-11.8	-8.4	2.8	13.1	11.7	0.4	1.6	5.2	2.6
-1	1.3	9	13.4	9.1	1.4	3.6	6.8	3.4
9.1	11.7	14.4	11.4	4.9	4.8	8.2	10.7	5.4
9.1	16.4	15.5	7.3	1.4	7.8	13	15.9	7.9
-0.3	9.7	10.2	3.5	0.1	9.3	16.1	19.9	10.1
-9.3	-0.1	4.9	1.3	-1.1	9	16.9	21.6	11
-17	-6.8	0.1	-1.3	-1.9	7.5	14.9	19.9	10.2
-23.8	-14.4	-6.8	-4.2	-2	5.2	10.9	15.6	8
-27.8	-21	-12.5	-6.9	-2	3.5	6.8	10.2	5.3
-27.9	-22.7	-15.4	-8.9	-2.2	2.9	4.5	5.8	2.9
-22.7	-19.1	-14.2	-8.2	-1.4	2.7	4	4.2	2.1
-15.1	-12	-7.6	-2.5	3.1	5.6	5.3	4.1	2.1
-10.3	-5.1	2.3	8.9	15.5	13.4	8.9	5.3	2.8
-5.2	-5.2	-0.7	9.2	18.4	16.9	11.1	7.2	4.4
-4.2	-4	-2.5	3.4	8.6	9.9	6.9	4.7	3
-2.1	0.1	-3.3	-2	0.9	2.6	1.1	0.1	0.2

October Zonally Averaged Wind Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	5.6	11	6.2	9.3	15.1	0.6	-23	-16.7
115	5.5	10.7	6.1	9.8	16.9	4	-17.4	-10.7
110	5.9	11.6	8.8	14.9	25	16.2	-0.2	7.2
105	7.9	15.9	15.8	24.3	36.2	29.1	15.6	23.2
100	9.6	18.9	19.8	28.6	40.4	32.1	18.6	25.8
95	9.1	17.5	16.9	23.9	33.1	23.2	8.8	16.5
90	6.1	11.6	7.7	12.3	20	9.4	-4.2	5.6
85	2.5	4.8	-6.8	-0.7	8.8	-3.3	-19	-3.7
80	0.8	1.7	-14.4	-5.3	2.4	-11.3	-31.9	-21.8
75	-0.8	-1.4	-14.9	-4	3.3	-6.5	-26.7	-26.7
70	-1.8	-3.5	-14.5	-0.3	9.4	3.7	-10.3	-11.1
65	-2.3	-4.4	-13.7	2.5	15.3	12.3	5.2	8.8
60	-1.4	-2.7	-12	4.7	19.3	17.7	11.4	13.3
55	1.5	3.2	-7.4	6.8	21.1	19.5	10.1	5.7
50	5.1	10.3	-2.2	8	20.1	19.2	8.7	0.4
45	8.9	18.2	4.2	9.4	17.8	17	8.3	-1.5
40	13.7	28	13.4	12.3	15.2	12.8	4.4	-6.9
35	19.1	38.8	25.4	16.6	11.8	6.1	-4.1	-15.9
30	22.7	45.1	35	21.2	7.9	-2	-10.6	-20.1
25	20.9	40	36.7	24.1	7.9	-3.7	-10.4	-16.9
20	15.1	28.8	33	24.3	12.8	4.3	-2.2	-9.9
15	11.4	22	24	21.7	21.7	22	16.3	2.5
10	6.5	11.2	18.1	23.8	24.5	24.3	16	2.1
5	2.5	4.4	10.8	16.5	15.5	11.6	4.8	-2
0		3.5	7	5.8	2.2	-0.6	-4.5	-4.7

October Zonally Averaged Wind Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
20.5	22	14.9	9.8	12.5	9.9	6.1	6.1	3.1
24	22.9	15.1	10	12.2	8.9	4.9	5	2.6
36.4	29.5	20.3	16.2	17.1	11.8	6	4.9	2.5
48	36.7	27.3	25.2	26	19.5	11.7	8.4	4.2
48.5	36.1	27.9	28.1	30.6	24.6	16.3	11.6	5.9
39.8	28.8	22.4	24.5	28.6	24.1	17	12.7	6.4
31.2	22.4	17.6	21	25.9	22.3	15.8	12	6.2
22.1	18.1	16.2	21.6	27.4	22.7	15.3	12.4	6.3
-5	-0.5	8.3	23.2	33	26.6	17.3	16.3	8.1
-17.6	-7.5	9.5	28.5	38.2	31.6	21.8	21.4	10.7
-8.8	3.1	19	34.1	42.3	37.5	26.7	25.3	12.7
8.6	20.3	31.6	37.4	43.1	42.8	33.2	30.5	15.2
13.7	27.8	37.5	37.9	42.6	46.4	39.9	36.8	18.4
6.7	23.8	35.2	37	42.2	47.1	43.9	41.8	21
-1	17.5	32.1	35.4	38.6	44.6	44.9	43.8	22.2
-6.3	11.4	27	31.3	32.5	38.9	41.7	41.4	21.3
-13.5	2	17	23.3	25.6	30.7	33.7	34.6	18
-22.3	-10.1	4.6	13.4	18.2	22	23.3	24.9	13.1
-27.7	-18.4	-5.1	4.6	11	14.7	16	16.7	8.6
-23.7	-16.6	-7.6	0.4	6.9	10.4	11.8	11.8	6.1
-17.1	-10.2	-2	3.6	8.5	10.5	10	8.5	4.4
-11.4	-1.9	9.8	16.1	18.6	16.4	11.7	7.2	3.7
-4	-2.5	5.8	16.4	19.1	18.2	13.9	9.6	5.9
-3.9	-4	-0.1	6.4	9.8	11.9	9.1	6	3.7
-1.9	-1.6	-4.1	-1.9	1.3	3.6	1.5	0	-0.3

November Zonally Averaged Wind Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	2.6	5.2	5	11	13.5	1	-31.7	-45.1
115	2.7	5.4	5.7	12.6	16.5	6.1	-22.6	-35.6
110	3.4	6.9	8.9	18.4	26.2	21	0.7	-11.1
105	6.3	12.8	17.8	29.8	39.8	37.5	22.6	11.6
100	8.7	17.2	23.3	35.7	45.2	42.6	28.7	17.8
95	7.9	15.3	19.8	30.3	37.1	32.5	18	8.4
90	3.7	6.9	7	14.5	19	13.5	0.2	-5.9
85	-2.2	-4.3	-13.1	-8	-4.3	-9.3	-21.8	-19
80	-6	-11.5	-26.7	-25.1	-25.8	-30	-43.3	-41
75	-8.9	-17.4	-32.5	-31.2	-33.9	-37.5	-50.3	-51.4
70	-9.6	-18.9	-32.9	-30.6	-33.5	-35.9	-44.8	-40.3
65	-8.9	-17.6	-31.5	-28.9	-30.9	-31.9	-37.9	-27.4
60	-7.1	-14.1	-28.8	-26.4	-27.8	-29.3	-37.9	-27.7
55	-4.7	-9.4	-25	-23.6	-24.3	-26.1	-39.5	-36.2
50	-2.4	-4.6	-21.4	-21.6	-22	-21.8	-35.1	-35.9
45	-0.2	-0.4	-17.9	-19.3	-19.5	-16.7	-25.6	-26.7
40	2.2	4.4	-13.3	-16.2	-15.3	-10.5	-17.7	-21.1
35	4.8	9.8	-7.2	-11.4	-10.5	-7	-14.9	-22.2
30	7.2	14.3	0.9	-4	-7	-7.3	-14.2	-23.9
25	6.9	13.6	8.7	3.3	-2.6	-6.1	-11.8	-20.6
20	7.4	14.7	15.9	11.3	6.1	1.3	-5	-14.2
15	8.7	17.1	21.2	19.8	18.8	17.9	12.8	-0.9
10	4.1	9	16.3	22	22.5	21.2	14.3	2.3
5	0.7	2.2	8.9	15.5	14.6	10.1	4.2	-1.3
0		0.7	5.6	7	3.5	-1	-4.3	-3.7

November Zonally Averaged Wind Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
-7.5	22.7	20.7	3.4	-5.2	-13.4	-9.6	3.6	1.9
-4.7	20.1	17.1	1.3	-7.1	-15.4	-11.6	2	1
6.9	19.9	15.2	3.2	-4.4	-13.5	-10.9	1.7	0.9
19.4	22.5	17.6	10.7	4.7	-4.8	-3.9	6.1	3
21.8	21.7	18.2	15.4	11.4	2.7	2.7	10.6	5.3
13.9	16.5	16.2	16.6	14.8	7.1	7.1	14.1	7.1
4.5	12	16.1	19.6	19.7	12.6	12.2	17.7	8.8
-3.1	12.3	20.5	28	30.4	20.7	17.3	22.3	11.1
-26.9	-0.9	16.9	35.3	42.2	27.2	20.4	26.7	13.3
-39.1	-5.2	20.9	45.7	51.5	34.2	24.3	28.9	14.7
-26.8	7.8	34.2	58.2	60.6	41.8	27.6	28.8	14.6
-11.9	22.3	48.5	68.2	67.5	48.8	31.4	28.6	14.4
-8.7	25.1	52.5	70.9	70.7	54.7	36.3	30.4	15.2
-15.8	17.9	47.9	68.9	72.2	58.4	41.3	34.4	17.2
-19.7	12.4	43.5	65.2	70.5	59	44.6	38	19.1
-15.6	13	39.4	58	63.2	54.3	44.2	39.5	20.1
-13.8	11.3	31.4	45.4	50.3	44.8	39.4	37	19.1
-17.8	2.2	18	28.8	34.5	33.8	32.3	30.8	16
-23.4	-8.4	5	14.1	20.2	23.2	25	23.4	12.2
-21.6	-10.4	-0.3	6.3	12.4	16.3	18.1	16.4	8.5
-15.6	-4.9	3.1	7.7	12.8	14.3	13.8	11.3	5.8
-8.4	5.6	17	21.7	22.4	17.7	12.9	7.4	3.8
-2.7	0.2	12.7	24.4	22.8	17.9	13	7.7	3
-3.5	-3.5	2.9	10.4	12.4	11.9	8.6	4.3	0.8
-1.8	-3.6	-4.8	-1	2	3.2	1.3	0.2	-1.7

December Zonally Averaged Wind Speed (m/s)

Height (km)	80S	70S	60S	50S	40S	30S	20S	10S
120	-0.6	-1.1	2.3	10.7	14	3.3	-25.9	-30.1
115	-0.4	-0.7	3.2	12.5	17.6	9.4	-15.2	-18.9
110	0.8	1.6	7.3	19.3	28.1	25.9	10.9	8.4
105	4.4	8.9	17.5	32	43.3	43.9	35.3	33.4
100	7.4	14.7	24.6	39.2	50.2	50.7	43.4	41.3
95	6.5	12.6	21.4	34	42.3	40.4	32.7	32.2
90	1.6	2.8	7.6	16.9	22.3	19.3	13	17
85	-4.5	-8.7	-17.8	-11.4	-5.7	-7.7	-11.1	3.8
80	-8.5	-16.4	-38.9	-38.9	-36.3	-34.8	-32.9	-12.1
75	-11.7	-22.6	-49	-52.4	-53.7	-50.6	-42.1	-20.4
70	-12.6	-24.8	-51	-54.2	-57.4	-55.9	-45	-21.4
65	-12.1	-23.9	-49	-50.9	-53.7	-56.1	-51.2	-29.9
60	-10.5	-20.8	-45.3	-46.2	-48.3	-56.6	-63.1	-47
55	-7.8	-15.6	-40.6	-41.4	-43	-55.3	-71.7	-62.1
50	-5.1	-10.2	-35.5	-36.7	-38.1	-51	-70.7	-63.9
45	-3.1	-6.2	-30.3	-32	-33.2	-43	-58.7	-50.7
40	-1.8	-3.5	-25	-26.2	-26.9	-32.8	-42.7	-36.8
35	-0.6	-1.3	-18.6	-19.3	-20	-23.6	-28.8	-28.6
30	-0.1	-0.2	-11.2	-12	-13.1	-15.7	-18.9	-22.4
25	-1.1	-2.2	-4.2	-4.9	-6.5	-9.2	-12.4	-15.4
20	0.3	0.5	3.7	4.5	2.6	-0.9	-5	-7.8
15	2.4	4.6	11.8	16.8	17.6	14.3	10.3	4.1
10	5	4.4	10.6	19.4	21.2	17.7	9	-0.4
5	2.2	0.6	7.5	15.3	13.9	8	1.9	-1.6
0		0.8	4.9	5.6	3	-1.2	-4.1	-2.6

December Zonally Averaged Wind Speed (m/s)

EQ	10N	20N	30N	40N	50N	60N	70N	80N
17	35.2	17.6	-4.5	-8.1	-25.8	-24.8	-4.2	-2.1
20.1	31.2	12.3	-7.9	-10.7	-28.6	-27.3	-6.1	-3.2
31.4	27.3	6.5	-7.8	-8.8	-26.7	-25.5	-5.7	-3
44.1	27.7	6.6	-0.7	1	-16.5	-16.9	-0.3	-0.2
47.4	26.8	7.6	5.5	9.4	-7	-8.5	5.4	2.7
40	22.9	7.6	9.6	15.9	0.8	-1	10.7	5.4
30.3	19.5	10.1	16.6	25.2	10.9	7.9	16.6	8.3
25.6	23.6	20.8	29.1	41.2	22.5	15	22.7	11.3
11.2	17.5	25.3	40.4	58.5	28.6	17.1	28.9	14.4
-0.6	13	29.6	55.5	69.3	35.4	19.6	32.7	16.5
-2.6	14.9	37.4	69.6	80.4	43.4	23.3	34.3	17.3
-9.7	13.2	41.6	76.4	88.1	52.8	28.8	35.7	18
-23.5	2.5	34.5	72.2	90.6	62.2	36.9	38.2	19.2
-36.2	-13.3	20.3	63.2	90.1	69.9	46	42.7	21.4
-40.2	-20.5	11.9	55.7	85.9	72.7	52.4	46.3	23.4
-32.2	-13.9	11.6	48.5	74.9	66.8	53	47.5	24.2
-25.2	-5.6	12.2	37.3	57.5	54.7	49.8	46.7	23.8
-23.4	-4.8	7.8	23	38	41.3	44.8	44.2	22.8
-21.6	-7.6	2.5	12.4	22.3	29.1	37.1	37.7	19.8
-15.1	-6.3	1.8	7.9	14.3	20.6	26.8	26.8	14.1
-6.5	0.4	6.2	10.4	14.7	16.8	19.3	18.6	9.6
2.7	12.1	21.2	26	24.9	18.6	15.6	13	6.7
-2.8	2.2	18.2	30.1	25.3	16.5	10.5	7.8	5.2
-3.7	-3.3	5.9	13.9	14.4	10.7	6.8	4.5	3.5
-1.8	-4.9	-4.9	0	2.9	3.2	1.5	0.3	-0.4

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